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CONTENTS

Page

Academic and Professional Mobility . . . 413

Ruminations on Radar. By Dr. R. L. Smith-Rose, C.B.E. . . . 415
Nerves and Muscles. By Dr. J. W. S. Pringle, F.R.S. . . . 416
Microbes and Drugs. By I. M. Rollo . . . 416
Medical Statistics . . . 417
Control and Compulsion. By Norman Cuthbert . . . 418
The Rat. By Prof. H. A. Harris . . . 419
The Hawfinch. By Sir Landsborough Thomson, C.B., O.B.E. . . . 419

Chemical Aspects of Selective Toxicity. By Prof. Adrien Albert . . . 421
Formation of a Helical Steroid Complex. By Drs. Alexander Rich and David M. Blow . . . 423
The Last Minutes of Satellite 1957β (*Sputnik* 2). By D. G. King-Hele and Mrs. D. M. C. Walker . . . 426

Obituaries :
Dr. W. S. Bauld. By Prof. G. F. Marrian, F.R.S. . . . 427
Prof. G. M. Wishart. By Prof. R. C. Garry . . . 427

News and Views . . . 428

The Fifteenth International Congress of Zoology. By Dr. Edward Hindle, F.R.S. . . . 434
The National Vegetable Research Station. By J. A. Nelder . . . 435
The Mechanical Engineering Research Laboratory. By R. J. F. Franklin . . . 436
Accurate Measurement of the Viscosity of Liquids. By Dr. E. W. J. Mardles . . . 438
The British Gelatine and Glue Research Association. By A. G. Ward . . . 439
Numerical Weather Forecasting . . . 440
Ribonucleic Acids in Liver Cytoplasm. By Dr. E. Reid and Barbara M. Stevens . . . 441
Age Determination for Individual *Mansonioides* Mosquitoes. By Prof. D. S. Bertram and W. A. Samarawickrema . 444
Induction of Respiratory Deficiency in Yeast by Manganese, Copper, Cobalt and Nickel. By Prof. Carl C. Lindegren, Susumu Nagai and Hideko Nagai . . . 446
Direct Observation of Dislocations in Graphite. By Dr. Alexander Grenall . . . 448
Further Inherent Characters of Plant Species of Wetter and Drier Habitats. By Dr. M. L. R. Pettersson and G. E. J. Gray . . . 450

Letters to the Editors :

β-Globulin Variants in Man.—H. Harris, E. B. Robson and M. Siniscalco . . . 452
High Resolution of Human Plasma Components by Starch Gel Electrophoresis.—Dr. J. M. Fine, J. Loeb and E. Waszczenko-z . . . 452
A New Method for resolving Amino-acids by Metabolism of Bacteria on Benzoyl Derivatives of DL-Amino-acids.—Prof. Yukio Kameda, Etsuko Toyoura, Katsuhiko Matsui, Yukio Kimura and Shizue Kitagawa . . . 453
Nuclear Changes occurring during Bud-formation in *Saccharomyces cerevisiae* as revealed by Ultra-thin Sectioning.—T. Hashimoto, S. F. Conti and Prof. H. B. Naylor . . . 454
Heinz Bodies in Extravasated Erythrocytes.—R. S. Smith, M. M. Boddington and A. I. Spriggs . . . 455
Antibiotic Substances from Yeast.—Werner Motzel and Dr. Elton S. Cook . . . 455
Recombination Ability of *Escherichia coli K*-12 Protoplasts.—Dr. Atsuyoshi Hagiwara . . . 456
Effects of Flavin Monosulphate and Flavin Adenine Dinucleotide on the Electroencephalogram.—Tsuneo Muramatsu, Moriaki Ando, Toshiharu Nagatsu and Kunio Yagi . . . 457
Activation of an Ascorbic Acid Concentrating Mechanism by Some Corticosteroids *in vitro*.—Leon S. Vann and Robert Hill . . . 458
Collagen in Human Cementum as shown by Electron Microscopy.—C. H. Tonge and E. H. Boult . . . 459
An Abnormal Hæmoglobin in a Chinese : Hæmoglobin *G*.—F. Vella, J. A. M. Ager and Dr. H. Lehmann . . . 460
Comparative Kinetic Behaviour of Thrombin, Plasmin and Trypsin toward Synthetic Substrates.—Dr. H. A. Scheraga, S. Ehrenpreis and E. Sullivan . . . 461
Vanadium Inhibition of Phospholipid Synthesis and Sulphydryl Activity in Rat Liver.—Fred Snyder and Prof. W. E. Cornatzer . . . 462
Relative Stability of Adrenaline, Noradrenaline and 5-Hydroxytryptamine subjected to Various Simple Treatments.—Daphne Joyce . . . 463
Application of Direct Photographic Photometry to Preparative Electrophoresis.—Dr. N. Ressler . . . 463
Co-ordination in Thorium-IV Acetylacetonate.—Prof. D. Grdenic and B. Matkovic . . . 465
Absorbents for Aldehydes and Olefins.—J. A. Kerr and A. F. Trotman-Dickenson . . . 466
Formation of a Transition Metal–Hydrogen Bond in Aqueous Solution.—W. P. Griffith, L. Pratt and Prof. G. Wilkinson . . . 466
A Radiocarbon Profile in the Tasman Sea.—D. M. Garner . . . 466
Vaporization of Projectiles on Impact.—G. Larikov . . . 468
Effect of Solar Flares on Earth Satellite 1957β.—T. Nonweiler . . . 468
Reversals of the Earth's Magnetic Field.—Dr. D. W. Allan . . . 469
Carbon-14 Activity during the past 5,000 Years.—Dr. C. Crowe . . . 470
Infra-Red Transmission Limits and Reflectivity of Lithium-6 Fluoride and Lithium-7 Fluoride—Dr. R. W. H. Stevenson and Dr. P. T. Nettley . . . 471
X-Ray Study of Rare Phosphate Minerals.—Dr. B. Mukherjee and U. Prasad . . . 472
Cultivation of Apple-fruit Tissue *in vitro*.—Dr. D. S. Letham . . . 473
Temperature Variations in Male Cones of *Encephalartos*.—Amy Jacot-Guillarmod . . . 474
Root Nodules of *Coriaria*.—Dr. G. Bond ; Dr. Pedro Montserrat . . . 474
Fluorescent Pigment of *Microsporum*.—Prof. Frederick T. Wolf, Ernest A. Jones and Helene A. Nathan . . . 475
Experimental Ringworm in Guinea Pigs : Oral Treatment with Griseofulvin.—J. C. Gentles . . . 476
Geographical Colour Polymorphism and Chromosome Constitution in Sympatric Species of Sawflies.—Dr. F. L. Waterhouse and Dr. Ann R. Sanderson . . . 477
Different Frequencies of Supernumerary Chromosomes in Diploid Populations of *Dactylis glomerata* in Israel.—Dr. Daniel Zohary and Israel Ashkenazi . . . 477
Spray-collecting Area of Locusts and their Susceptibility to Insecticides.—R. D. MacCuaig . . . 478
Microscopic Structure of the Lungs of the Bottlenose Whale.—J. R. Goudappel and Prof. E. J. Slijper . . . 479

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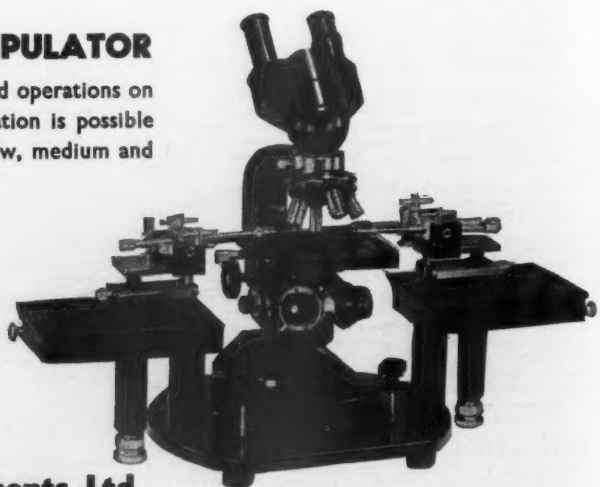

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ACADEMIC AND PROFESSIONAL MOBILITY

THE discussion on academic mobility at the Home Universities Conference last December*, the report of which was published early this year, originated in an inquiry of some members of the Association of University Teachers in 1956, which was briefly described by Dr. C. M. Rigby in opening the discussion. Out of 749 who replied, excluding assistant lecturers, 124 had had no other experience, and 50 of these had graduated in the university in which they were then teaching; 301 had had no experience of teaching in any other university, and of these 116 were graduates of the university in which they were teaching. Only 216 had experience of teaching in one other university, 81 of two other universities, and 27 of three or more other universities. While these figures relate to only about 8 per cent of the total staff of the universities of the United Kingdom, they indicate that possibly half the academic staff of these universities have taught only in a single university and 15 per cent only in the university in which they themselves graduated.

The inquiry thus suggests that university life in Britain is not being enriched by the movement of university teachers from one university to another to the extent that is desirable; indeed, during the discussion, Prof. R. O. Buchanan commented that mobility between Britain and overseas universities is easier and better provided for than mobility within the United Kingdom. He did not, however, suggest that even here the provision is adequate, and Dame Lillian Penson stressed the importance of mobility between the United Kingdom and countries overseas. She believes that we have now reached a very critical stage in the task the universities of the United Kingdom have undertaken since the War in helping to build up new universities in the Colonial and overseas territories. These territories are becoming genuinely independent and need help from Britain more than ever; but it may not be so easy to persuade people from British universities to make their careers overseas. This is partly due to the belief that their services in university institutions overseas will not be required for long, and Dame Lillian pointed out that we have not yet built up sufficiently a system for seconding experienced members of universities to these overseas universities for one or two years.

Dame Lillian's plea is fully endorsed by a relevant passage in the latest report on "The Colonial Territories, 1957–58". Commenting on this situation, Prof. Buchanan remarked on a difficulty which the Advisory Council on Scientific Policy noted in a wider context in its 1956–57 report. Pointing out that young scientists and technologists holding fellowships or studentships in the United States or Canada are discouraged from returning to Great Britain by the practice of requiring them to return for interview if they are to be considered for employment by British firms, the Advisory Council suggested that industry should set up an organization in the United States and Canada to interview graduates on behalf of United Kingdom employers. Prof. Buchanan obviously believes that such a measure would assist the return flow to Great Britain, but he points out that in actual practice the overseas Dominions and the Colonial universities and university colleges themselves get most of their staff from Britain, or from Canada, without local interviews. Instead, they rely on interviews in the country of origin of the candidates by people whose judgment they are prepared to trust. Prof. Buchanan thinks that on the whole the results are no worse than they are in Britain, where the appointing committees are interviewing committees also, and he suggested that the United Kingdom universities would do well to advertise their vacancies not only in the United Kingdom but also over the whole of the Commonwealth and in the United States, and to arrange for local interviewing committees for candidates from areas overseas. The reports of these overseas committees would then be studied in conjunction with the reports of their own interviewing committees on candidates in Britain. Prof. Buchanan recognized what is involved in this suggestion and the risks that would be incurred; but his suggestion of interviewing committees overseas was fully supported by Prof. H. C. Baldry, who was emphatic that this question of interview is at present a major obstacle—so much so that people in university posts overseas normally only move when they come to Britain on sabbatical leave. He also pointed out that the interruption of research involved in moving is serious, and can itself be an obstacle to mobility. The latter difficulty could be minimized to some extent by administrative action; but the importance of academic mobility, particularly in relation to the universities overseas, was well demonstrated in the discussion by the deep appreciation of representatives of such universities in the practical interest of the Conference.

Nor is the interest of the problem limited to the universities themselves. Academic mobility is itself one facet of that interchange of knowledge and culture which is an indispensable element in creative work, the importance of which was stressed by Sir George Thomson in his Fawley Foundation Lecture, "The Strategy of Research", last October. Apart from its contribution to good relations and understanding within and without the Commonwealth, interchange and movement contribute much to the communication of ideas and the stimulation of

* Report of the Proceedings of the Conference of the Universities of the United Kingdom, convened by the Committee of Vice-Chancellors and Principals, and held in the William Beveridge Hall, University of London Senate House, on 13th and 14th December, 1957. Pp. 111. (London: Association of Universities of the British Commonwealth, 1958.) 5s.

thought, and we would be wise to foster it as fully as possible.

That contribution was brought out incidentally by Prof. A. G. N. Fleur at an early stage in the discussion at the Home Universities Conference; but Dr. R. S. Aitken, vice-chancellor and principal of the University of Birmingham, from a study of data from Birmingham, believes that we may already have as much mobility in the science faculty as is desirable, but that in ten to twenty years time there may be an increase in stability at the expense of mobility unless the universities, in concert, extend to senior lectureships the practice of appointment from outside in preference to promotion already customary by many in connexion with chairs. This point was strongly urged by Prof. Fleur, who also suggested that the Association of University Teachers survey should be extended. We need, he thinks, more detailed information, and while undoubtedly too much mobility can lead to waste, its value in broadening the mind, stimulating experiment and reform and disrupting complacency is undeniable.

It is, of course, true, as Prof. J. L. Montrose remarked, that some of the advantages in mobility could be secured by more exchange in the universities between members of different disciplines; but there is clearly much that could be done by the universities themselves to remove existing hindrances to mobility, many of which, as Dr. Rigby pointed out, are personal or domestic. One difficulty, however, requires wider action, and that is the matter of pension schemes, mentioned by Dr. Rigby but developed more fully by Dr. B. V. Bowden, who referred to the constant interchange of staff between the Manchester College of Science and Technology and industry. This movement is encouraged by all possible means and the College seeks to replace those who leave by people from industry, regarding this as an essential part of the operation of the College. It is important, said Dr. Bowden, that people should come and go between education and industry several times during their professional life, but such interchange is often rendered very difficult by inflexible pension schemes. Representations have been made through the Institute of Actuaries, the University Grants Committee and the Federation of British Industries to try to get something done in the Millard-Tucker Committee, but income tax law makes it extremely difficult for pension schemes to be made portable, particularly in a time of inflation.

Dr. Bowden suggested that the problem deserves much more serious study than it has yet received; but it is also clear that here is one of the points at which Government action could be decisive. Dr. Bowden's remarks also indicated the bearing of academic mobility on the expansion of higher technological education and on education policy generally. He referred specifically to the value of movement not simply between the universities and the colleges of technology and industry but also between the universities and the schools. Factors which hinder movement between the universities and industry can equally hinder the movement between the universities and the schools, and if only for its bearing on the shortage of science teachers, the problem is one that demands the attention of Government in its approach to the expansion of university, technological and technical education.

Academic mobility should not be regarded, in fact, as simply a matter of movement between the universities in the United Kingdom and overseas. It should be considered rather as a matter of promoting the movement of trained men and women, so that they gain the wide experience and varied stimulants they need for the full development of their professional capacity. It should include movement to and from the Government service, the research associations, the technical colleges and industry as well as between universities and the colleges of technology. Upon the care with which it is fostered depends in no small degree the most effective use of the limited resources of trained men and women, and equally the ability to increase these resources both generally and in the particular categories in which they are most urgently needed.

These questions were brought in relation to one particular type of scientific worker in a discussion arranged by the Institute of Biology, a report of which was published in the Institute's *Journal* early this year (see *Nature*, 181, 677; 1958). Dr. E. E. Weatherby's address in particular shows the importance of academic mobility for professional men in general who are seeking service overseas. The matter will require much greater attention than it has yet received before we can hope to find that sufficient numbers of professional men and women are prepared to venture overseas, not merely to serve in universities and other educational institutions but also in other spheres, including the research institutions, many of which are closely linked with the overseas universities and university colleges.

As Dr. Weatherby pointed out, in the re-organization of the Colonial Service the Government has sought to deal with the important issue of security, but only a beginning has been made and much yet remains to be done. Any action the universities may themselves take to encourage academic mobility may well have an effect far outside their walls, particularly in so far as movement to and from the overseas university institutions is concerned; but there are difficulties, notably in security and in regard to pensions, which only government action is likely to solve. Such action is desirable, and indeed imperative, if Britain is to play her full part in assisting the overseas territories to develop their resources and to build up universities and colleges, research institutes and other public services with high standards and great traditions; it is also essential to enable Britain to take a fitting part in technical assistance to the under-developed countries, either under the Colombo Plan or the United Nations. It may equally determine whether we are able to develop what has well been described as our most important and vital export to-day, namely, that of trained man-power, on which will largely depend how far we can make full use of

such assets as we possess in nuclear power and like developments.

Ultimately, however, the reason for fostering the movement of trained men and women, between the universities of the United Kingdom and overseas, or between university institutions and industry, the Government service, research institutions, and other walks of life, lies in the contribution it makes to the stimulation of creative thought and the quest for new ideas. Beyond even the contribution to international understanding, this factor is all-important if mankind is to regain control over events. We cannot afford to neglect any means that promise to stimulate creative and imaginative thought, the receptivity to new ideas, sound judgment and the open mind. The expenditure required to remove some of the obstacles is trifling compared with the benefits which the nation and indeed all mankind might well reap, and it is to be hoped that the lead which has already been given will be assiduously followed up by professional associations as well as by the universities and also by such bodies as the Parliamentary and Scientific Committee. At the least, Government policy should be directed towards ensuring that, so far as administrative action can provide, the fullest freedom exists for the contact of trained minds, the communication and discussion of ideas, not only through the printed word but also in those personal contacts which the evidence of the centuries has shown to be so fruitful and stimulating.

RUMINATIONS ON RADAR

Three Steps to Victory

By Sir Robert Watson-Watt. Pp. 480+25 plates. (London: Odhams Press, Ltd., 1957.) 30*s*. net.

THIS book is a combination of an autobiography and a documentary history of the development and applications of radar, intended to clarify the part played by the author and various colleagues. After soliloquizing in an introductory chapter on the theme "Happiness is No Private Enterprise", the book starts somewhere in the seventeenth century and proceeds to beyond 1952 in a final chapter entitled "Happiness in Private Enterprise". But the progress from one end of the book to the other is by no means linear in time. It can be regarded as covering forty years of the author's life, during which the idea of radar was born, forced rapidly through a lusty boyhood, and on to a most vigorous manhood to play its outstanding part in the Second World War and after. The important events are related not in strict chronological sequence, but almost as the author reminds himself of outstanding milestones combined with what many would regard as trivial memories of irresponsible deeds or conversations. We travel backwards and forwards through this period of time in a manner which may not be disturbing to one who, like myself, has lived through the same period and in some sort of touch with the subject. Indeed, having spent almost exactly this period of forty years, oscillating in a very erratic manner between the National Physical Laboratory and the Radio Research Station, where some ten years of the action was played, I found the book of considerable interest. Whether the so-called 'plain man' for whom it is supposed to be written will do so is more questionable; and especially is it doubtful whether the reader of the future, anxious to study the history of the subject, will find it easy to secure an orderly array of the wide range of facts presented to him.

But it is time to tell the reader of this review what the book is about. In the course of seventy-six chapters, and nearly 500 pages, it presents a most attractive and detailed account of the author's reflexions on the outstanding part which radar played in determining the outcome of the Second World War; and for which he and a syndicate of colleagues associated with him received a not inconsiderable financial award. The "Three Steps to Victory" were: first, the instantaneous visual direction-finder developed for locating the sources of atmospherics and belatedly patented by the author in 1924; secondly, the demonstration of radar and its development into a military weapon that revolutionized the art and practice of war in the air, at sea and on the ground; and thirdly, the application of the technique of operational research, which brought the back-room scientist into the planning as well as into the analysis of the day-to-day operations of war.

The main theme of the book is centred around the second of the above items. After preliminary thinking and discussion, a demonstration was given on February 26, 1935, by A. F. Wilkins—the author's closest and most active colleague in all the early work—of the possibility of detecting aircraft by reflexion of radio waves. This experiment was, however, merely to confirm the sound basis of a memorandum entitled "Detection and Location of Aircraft by Radio Methods" which was considered on the following day (February 27, 1935) by the British Committee for the Scientific Survey of Air Defence. This memorandum, which is reproduced as an appendix to the book, is regarded by the author "as marking the birth of radar and as being, in fact, the invention of radar". From this point, the book describes the trials, tribulations and successes which accompanied the conversion of an interesting scientific technique into a practical application, with the tools and equipment placed in the hands of, and entirely operated by, military personnel. The story is told in the author's inimitable style, generally interesting, but sometimes rather involved and not easy to follow. He is naturally reviewing the events with the advantage of his own 'hindsight', but still endeavouring to describe the foresight which was used and applied at various stages of development. Much of the story is supported by references to published and unpublished material, and also to conversations in various high official places. In some cases the speakers who may have commented either lightheartedly or in the heat of an important and urgent discussion may be surprised to find their remarks recorded in cold print.

Chapter 45, with the intriguing title "My Greatest Mistake", explains how the first step—the 'C.R.D.F.' or visual direction finder—was not applied in practice until the middle of the War on account of the pressure of other techniques, followed by the difficulty of making changes once manufacture had started. But the realization that the time of travel of a rocket ($V2$) from firing site to target would be only a few minutes soon brought the 'C.R.D.F.' set out of its

'cold storage'. Another interesting chapter entitled "Hawaiian Week-end" gives a brief account of the Japanese attack on Pearl Harbour on December 7, 1941 (not 1940 as on p. 311), and this is used to illustrate the limitation of the human element in collecting and acting upon information provided by radar. Looking back from the present time, it requires a mental effort to realize the lag of the United States behind Britain in the initial application of radar. As early as the autumn of 1937 it was clearly accepted at the highest professional level that radar was an invaluable and indispensable element in the defence of Great Britain; but four years later the corresponding value and indispensability had still not been recognized in the United States.

To some readers the book may appear to be egotistical; but it is perhaps inevitable that an autobiography must make very frequent use of the first person pronoun. I thank the author for his introduction to a number of unusual words, some of which I found defined in the dictionary; and I was interested to learn that the National Physical Laboratory is an "oddly schizoid institution". The book is a long one for the 'plain man' to read, but perhaps the author's attitude is similar to that of another author (of radio technical books) who once remarked to me: "Maybe there are twice as many words as are necessary, but the reader either gets it that way or not at all". The long text is relieved by a number of most interesting photographs of places and personalities associated with this particular story of radar.

R. L. Smith-Rose

NERVES AND MUSCLES

Comparative Physiology of the Nervous Control of Muscular Contraction

By Dr. Graham Hoyle. (Cambridge Monographs in Experimental Biology, No. 8.) Pp. viii+147. (Cambridge: At the University Press, 1957.) 15*s*. net.

THE science of comparative physiology may be said, broadly, to have two objectives. It attempts, on one hand, to describe in an analytical manner the normal working of the variety of animal species, and so to supply evidence, of a different kind from that derived from the study of comparative anatomy, which may help to suggest evolutionary trends. On the other, comparative physiologists attempt, by making use of the variety of physiological processes found in the animal kingdom, to discover the fundamental physico-chemical mechanisms at work in living matter, choosing their material for each investigation so as to take advantage of the peculiar advantages offered by life's variety for the elucidation of its common features.

Dr. Graham Hoyle's monograph on the "Comparative Physiology of the Nervous Control of Muscular Contraction", the eighth in the series of Cambridge Monographs in Experimental Biology, provides an excellent example of an inquiry with the second objective. The field embraced, which is the functional connexion between nerve and muscle, might seem at first sight to be a narrow one; but, as the author points out in his preface, "since a myoneural apparatus is present in all phyla except the Protozoa and the sponges, there is a wide range of animals in which to study the problems". These problems have been intensively studied in recent years in one or two animal types, and a truly comparative review of the whole animal kingdom was certainly called for.

It is taken as axiomatic that the nervous control of muscle *excitation* is an essential stage in the control of muscular *contraction*, and the greater part of the book is concerned with the process whereby the arrival of a nerve impulse at the neuromuscular junction initiates a change in the electrical potential across the surface membrane of the muscle fibre. The full analytical framework used to interpret experiments on neuromuscular physiology is set out about half-way through the book on pp. 67–68. Dr. Hoyle precedes this with one valuable chapter on comparative histology and three on the general biophysics of excitable membranes, which are necessary for an understanding of the myoneural mechanisms. He then goes systematically through the Metazoan phyla, showing how far it is possible to interpret the different mechanisms as variations on the common theme. It could be objected that the framework is derived too largely from detailed studies on the vertebrate and crustacean junctions, and that the provisional assumption that the "broad principles . . . have universal application" is a dangerous one. The immediate answer is that no other analytical framework has yet been suggested, and that it is strength rather than weakness in a hypothesis that it should be clearly stated and be amenable to verification or refutation.

In his last chapter Dr. Hoyle touches on the remaining parts of the control sequence, such as the coupling of muscular excitation to contraction, and the problem of contractility itself. He also discusses the evolution of the myoneural apparatus and mechanisms, and is left with the impression that this has been concerned almost exclusively with modifications of existing parts, the essential features of the architecture and function of the junctions either having reached a satisfactory standard at an early stage, or representing the only possible system. It is, of course, valid to discuss evolutionary trends only in a very broad context of the working of the animal as a whole, and this is only briefly attempted. Within the precise field which it covers this monograph is, however, a valuable addition to the none too plentiful literature on comparative physiology.

J. W. S. Pringle

MICROBES AND DRUGS

Ciba Foundation Symposium on Drug Resistance in Micro-Organisms

Mechanisms of Development. Edited by G. E. W. Wolstenholme and Cecilia M. O'Connor. Pp. xii+352. (London: J. and A. Churchill, Ltd., 1957.) 50*s*. net.

Drug Resistance of Microorganisms

By Robert J. Schnitzer and Emanuel Grunberg. Pp. xiv+395. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1957.) 10 dollars.

"CHEMOTHERAPY has still many problems to solve . . . [the greatest perhaps] is how to prevent the rapid development of resistant strains of parasites in relation to the action of specific chemotherapeutic remedies." Thus did Findlay in 1950 express the

concern of those whose work is the discovery and development of such agents. Despite the importance of drug resistance and the amount of published work which has appeared, there has been, until now, no text-book available for reference or instruction. Drug resistance has been considered in many surveys of chemotherapy, but these have of necessity covered only the broadest outlines of techniques and results, and even less of the mechanisms of development. The publication of both these books is therefore timely.

It is a disquieting admission that chemotherapy is still, after more than half a century of vigorous life, essentially an empirical science. This fact is probably a constant source of intellectual discouragement to the chemist who may be successful in his search for an effective chemotherapeutic agent but who at the same time has little or no idea of the mode of action of that agent. Such success may also bear little or no relation to the thought that has gone into his research. A further source of discouragement may be the emergence of resistance to an otherwise excellent drug. It is generally felt that the answer to this problem can be found only by biochemists and microbiologists.

For this reason, therefore, the Ciba Symposium on Drug Resistance in Micro-Organisms (Mechanisms of Development) was arranged with participants from America, Europe and the U.S.S.R. The first book under review is the result of this Symposium and contains, as is usual in the Ciba Symposia reports, both original papers and ensuing discussion. The papers, representing the efforts and views of leading workers in this field, cover a very wide range of subjects from the general—Dean and Hinshelwood's "Aspects of the Problem of Drug Resistance in Bacteria" and Demerec's "Genetic Aspects of Drug Resistance"—to the particular—Alexander, Cousens and Stacey's "Reactions of the Mutagenic Alkylating Agents with Proteins and Nucleic Acids". It is invidious, however, to select individual papers—there are eighteen altogether—since the standard is uniformly high and the ensuing discussion controversial and stimulating. There is an understandable tendency, however, to concentrate on the academic rather than the practical aspects throughout; understandable since so little work has been done in the field to deal with the problem of resistance. This is gently pointed out in the final general discussion by Lederberg, whose remarks constitute a crystallization of the more practical issues. The main value of the Symposium seemed to be a reconciliation between the two main schools of thought as to the prime responsibility of genetic mutation rather than phenotypic adaptation for resultant resistance.

The second book is an encyclopædic work on the experimental approach to the study of drug resistance. After a brief but valuable appraisal of the history and various aspects of drug resistance, the authors exhaustively set out the methods used for the production of resistant strains of protozoa, spirochætes and bacteria, and discuss the properties of such strains.

The third and longest section of the book is devoted to mechanisms of resistance with particular emphasis on specificity and cross-resistance. There can be no doubt that a considerable amount of information can be obtained about the mechanism of antimicrobial action of substances from a study of specificity and cross-resistance, and this is well brought out here. Further evidence can be obtained from studies on drug antagonism and synergy; these aspects are also discussed. The brief section on theories of drug resistance describes some of the general hypotheses now in vogue and makes stimulating and thought-provoking reading. This is a book which should be on the desk of every worker in the field of chemotherapy.

I. M. Rollo

MEDICAL STATISTICS

Manual of the International Statistical Classification of Diseases, Injuries and Causes of Death

Based on the Recommendations of the Seventh Revision Conference, 1955, and adopted by the Ninth Health Assembly under the WHO Nomenclature Regulations. Vol. 1. Pp. xli+394. Vol. 2: Alphabetical Index. Pp. xxvi + 540. (Geneva: World Health Organization; London: H.M. Stationery Office, 1957.) 35*s*. (2 volumes).

CLASSIFICATION, which is fundamental to the quantitative study of any phenomenon, has presented particular difficulties when applied to the study of illness and death. A statistical classification of disease must be of manageable proportions; it must be arranged in such a way that the important disease processes can be examined numerically; it must be designed so that every condition will find a place somewhere; and it must restrict entries to conditions of importance by reason of their frequency or gravity. It differs, therefore, from a medical nomenclature, which should provide a catalogue of terms both detailed and extensive, with an encyclopædic quality which must hinder rather than aid statistical calculation.

But perhaps the greatest difficulty in classifying disease lies in the absence of any unifying system. Any classification is inevitably a compromise between a number of conflicting points of view, of differences of opinion as to etiology, anatomy, clinical features, age, etc. Thus no systematic classification of disease is practicable.

"The medical practitioner may found his main divisions of diseases on their treatment as medical or surgical; the pathologist, on the nature of the morbid action or product; the anatomist or the physiologist on the tissues and organs involved; the medical jurist on the suddenness or the slowness of death; and all these points will deserve attention in a statistical classification." (William Farr.)

Even this does not end nosological difficulties. The classification must also have regard to the variations in medical terminology—as between medical men of different vintage or varying specialities or countries. The neoplasms in Britain and elsewhere are varyingly named according to the view as to the pathological process involved; anthrax in French-speaking countries is a staphylococcal infection of the skin and in English, German and other languages it denotes an infection by *Bacillus anthracis*. So many varieties of clinical description of mental disorders are in use in different countries that no one classification could completely satisfy everyone.

Classification of disease must also be bound by expediency—seeking to fit diseases into a framework which aids comparative measurements. Thus influenza and pneumonia are grouped under diseases of the

respiratory system and not under infective diseases, mainly because of their close association with acute upper respiratory infections, so many of which are of unknown etiology. Rheumatic fever, for a like reason, has recently been classified with diseases of the circulatory system—because of the cardiovascular sequelæ of the disease—although as a disease of connective tissue it might stand on its own. Degenerative vascular changes manifest themselves as hypertension, arteriosclerosis, cardiac and renal affections or lesions of the central nervous system—it is mere convenience to include cerebral hæmorrhage under diseases of the nervous system; chronic nephritis under diseases of the genito-urinary system; and hypertension under diseases of the circulatory system —although the pathological processes in the body may not be greatly dissimilar.

It follows from these illustrations of the difficulties to be found in classifying disease not only that international agreement can have been achieved only after long discussion, but also that adjustments to any agreed classification will be made with circumspection and must wait upon advances in medical knowledge which have general acceptance.

The outstanding event in a hundred years of international deliberations on the classification of diseases, injuries and causes of death must be accounted the Sixth Revision which appeared in 1948. This was not only the first with anything like world-wide acceptance, but also it provided the first statistical classification for both morbidity and mortality. The Seventh Revision of the International Lists of Diseases and Causes of Death, resulting from the international conference held in Paris under the auspices of the World Health Organization (February 21–26, 1955), which appears in two volumes (classification and index), has made little change in the 1948 manual. The classification is arranged somewhat eclectically in seventeen main sections: the first consists of well-defined infective agents; then follow categories for neoplasms, allergic, endocrine, metabolic and nutritional diseases, with the remaining diseases classified according to their principal anatomical site—nervous, circulatory, respiratory, digestive, genito-urinary systems, the skin, the bones, and congenital malformations. There are special sections for mental diseases, complications of pregnancy and childbirth, certain diseases of early infancy, senility, etc., and accidents, poisoning and violence. The detailed list (pp. 1–42) consists of 612 categories of diseases and morbid conditions, numbered on a decimal system with three-digit numbers. The first two digits present summarily important groups that are significant, and the third digit represents specific disease entities. Thus under deliveries and complications of pregnancy, childbirth and the puerperium (represented by 640–689) complications of pregnancy begin with the digits 64 and those of the puerperium with 68—nine disease entities under each heading being further represented by a third digit. The tabular list of inclusions (pp. 45–353) gives the framework of the classification and lists the conditions included in each category of the detailed list.

The first volume also includes an account of the international agreement on medical certification and the rules for classification. This is in itself as important as the classification, since it greatly affects the validity of certification and the comparability of results.

The introduction to Volume 1 provides a readable, if rather too brief, account of events leading up to the present position and the particular steps which the World Health Organization is now taking to improve the validity of statistics dealing with sickness and death, including the Expert Committee on Health Statistics, National Committees on Vital and Health Statistics, and the World Health Organization Centre for Classification of Diseases. For more detailed information the reader is referred to other publications in a list of references. These also might be strengthened by reference to other documents. Otherwise the World Health Organization has produced an unexceptionable work of great significance to the measurement of health.

CONTROL AND COMPULSION

Economic Planning by Programme and Control in Great Britain

By Prof. Gilbert Walker. Pp. xii+175 (4 plates). (London: William Heinemann, Ltd., 1957.) 18*s*. net.

PROF. GILBERT WALKER brings together in remarkably small compass the main features of government planning and control in Great Britain during the Second World War and the years immediately following it. The early chapters, comprising about one-third of the book, trace the development of economic thought on the problem of unemployment and poverty, explain the use of social accounts as a tool in making policy decisions, and describe the operation of controls in the mobilization of resources during the War. The remainder of the book is concerned with the planning techniques designed to aid a smooth transition from war-time to peace-time conditions and to avoid the boom and slump which followed the First World War.

An inevitable result of trying to cover such a wide field is that the treatment of certain topics suffers from too much compression. For example, the casual reader of Chapter 2 might conclude that the consequence of an increase in income will be the same whether it arises from increased wage-rates or from increased production. Similarly much benefit would be derived from a short section reviewing the changes which occurred in Britain's position as a result of the War and made the continuance of controls necessary.

The author's assessment of the desirability of economic planning emerges towards the end of the book. Government control is practicable in war-time. But in peace-time:

"Democratic governments, determined to remain within the letter and the spirit of the Western tradition, but bent nevertheless on assuming a deliberate and positive control over the direction and magnitude of economic change, have to find the means, other than compulsion, of ensuring that citizens, obeying whatever impulses may move them, freely choose the courses which correspond to the employment of resources marked out by the planners."

The antithesis between Western tradition and compulsion is a false one. Western democracies have long used compulsion in ordering economic life. That a considerable amount of planning was carried out after the War without active compulsion says a great deal for the flexibility of the plans and the good sense of those responsible for their execution. Powers of compulsion, however, existed and although

unused they may well have contributed to the success of the Government's economic policy.

Prof. Walker's publishers state that he has written this work with the object of interesting the wider public; many professional economists also will find most useful and enlightening its descriptions of the mechanism of controls and its assessment of their effectiveness.

NORMAN CUTHBERT

THE RAT

Anatomy of the Rat

By Eunice Chace Greene. (Originally published in 1935 as Volume 27 (New Series) of the Transactions of the American Philosophical Society.) Pp. xi+370 (339 figures). (New York and London: Hafner Publishing Company, 1955.) 25 dollars; £9.

The Genesis of the Rat Skeleton

A Laboratory Atlas. By Donald G. Walker and Zolton T. Wirtschafter. Pp. vi+59 (53 plates). (Springfield, Ill.: Charles C. Thomas; Oxford: Blackwell Scientific Publications, 1957.) 57*s.* 6*d.*

THE "Anatomy of the Rat", by Mrs. E. C. Greene, is essentially an atlas and a text-book in quarto form. The text and illustrations occupy about the same space. When this book appeared in 1935 it provided the most complete account of the anatomy of the rat and was a most valuable supplement to the second edition (1924) of H. H. Donaldson's "The Rat". The latter was a mine of quantitative information, presented in tabular and graphic form, for the weights and dimensions of various parts of the body from birth to maturity. In fact, Donaldson presented more pertinent and accurate data on the rat than was available elsewhere for man. His bibliography extended to about 2,000 references. Since then the number of references has more than doubled, for the Wistar rat was adopted as the favourite child of the experimental psychologists. The rat, particularly the Wistar and the Evans–Long strains, knew on which side his bread was buttered.

"Anatomy of the Rat", long out of print, has been reprinted and is now priced at 25 dollars as compared with 5 dollars in 1935. The minor blemishes of the first edition persist; the usual failure to appreciate the genetive form of Latin and Greek words is as before. The removal of these minor blemishes and a few errors of fact may be looked for when a new edition of the book appears. The only weakness in this best of books is the lack of detailed information on the brain, which has assumed great importance as a result of the work of experimental neurologists such as Lashley in Chicago.

"The Genesis of the Rat Skeleton", by Walker and Wirtschafter, of the University of Oregon Medical School, is an attempt to depict the orderly progression of appearance of centres of ossification by radiographs and photographs of alizarin-stained specimens. Little has been added to the data presented by Donaldson in his second edition of "The Rat" (1924), by R. M. Strong (1925) and by A. B. Dawson (1925–34).

This atlas measures 18 in. × 12¼ in. and presents an elegant format and Hollywood calligraphy which is tiring to the eyes, especially for such new words as "Corocoid" and "sternabræ". The radiographs and photographs are not satisfying. Radiographs will not stand photographic enlargement to more than three diameters, as the appearance of the emulsion grain obscures the details of the bony structure.

The portrayal and labelling of the centres of ossification in the skull are inadequate. A prior knowledge of the chondrocranium is essential in order to see how the bony centres arrange themselves in relation to the issuing cranial nerves which maintain a foramen between two or three bony anlage in the skull base. Likewise, the membrane bones appear precociously as two-dimensional unilaminar sheets to guarantee the two-dimensional distribution of the overlying nerves. The absence of any anatomical text is a serious objection to this atlas, for an atlas calls for a system.

H. A. HARRIS

THE HAWFINCH

The Hawfinch

By Guy Mountfort. (The New Naturalist.) Pp. xii+176+8 plates. (London: William Collins, Sons and Co., Ltd., 1957.) 18*s.* net.

VERY much can be learnt by concentrating on a single species of bird and studying every aspect of its life, and in Britain there have recently been several admirable monographs giving the results of such work; of these, the present volume is a fine example. Although an enterprising all-round ornithologist with much else to his credit, the author has for long had a particular enthusiasm for the hawfinch. This has been the more repaying in that the species is one of the least familiar of our not uncommon birds—partly because of its wary and elusive habits, and partly because of its very local and rather erratic distribution. Many years of close observation have now enabled Mountfort to present a fascinating picture.

The hawfinch is notable for its large bill, allied with a massive skull and powerful jaw muscles. This arrangement is related to the habit of cracking cherry stones and olive kernels, a feat which the author's collaborators have shown to involve crushing loads ranging from 60 to 159 lb.—and this in a bird weighing a couple of ounces! It is also a strong flier, capable of an almost vertical take-off and of bursts of speed approaching 40 m.p.h.; the wing area is small relatively to weight, and the beats are rapid.

The species succeeds in combining richly coloured plumage, in both sexes, with a perfected habit of stealthy self-effacement. Yet in its own winter flocks and towards other species it is notably aggressive: one of Eric Hosking's photographs, which are among the illustrations, shows a bird leaping forward with snapping bill to put a much larger mistle-thrush to flight. There is also an elaborate courtship ritual, comprising a number of characteristic attitudes—fluffing of throat feathers, a 'penguin' walk, a deep bow of appeasement, an approach with dragging wing-tips, and a bill-touching ceremony. Also described in detail are the various phases of the nesting season, the song and call notes, the diet and feeding habits, together with distribution and migratory movements in Britain and elsewhere. An appendix by John Barlee deals with the flight.

It is unfortunate that, owing to publication costs, a bibliography of 650 titles could only be deposited.

LANDSBOROUGH THOMSON

Population Redistribution and Economic Growth, United States, 1870–1950

1: Methodological Considerations and Reference Tables. By Everett S. Lee, Ann Ratner Miller, Carol P. Brainerd, and Richard A. Easterlin. Prepared under the direction of Simon Kuznets and Dorothy Swaine Thomas. (Memoirs of the American Philosophical Society, Vol. 45.) Pp. xx+760. (Philadelphia: American Philosophical Society, 1957.) 5 dollars.

THIS massive collection of data forms the first part of a larger study to be prepared under the direction of Profs. Kuznets and Thomas. As the title indicates, its primary function is methodological, and the provision of the basic data. Analysis and theoretical evaluation will have to await the appearance of the second volume in the series. Well over half the present volume consists of reference tables, and there is an explanatory text which shows in detail how the tables have been computed.

The tables treat four principal topics. For each of the 48 States and for the District of Columbia there are comparable series from 1870 to 1950 giving estimates of internal migration, figures relating to the labour force, estimates of manufacturing activity and State income estimates. The amount of detailed statistical work that has gone into the preparation of these figures must have been enormous, and there is no doubt that these tables will form a most important work of reference for anyone working on the history of the American economy. In addition to the topics mentioned, there are figures relating to the rural and urban population of each State, to the agricultural and non-agricultural labour force, the number of manufacturing establishments, total wage bill of employees, income per head in various categories and so on. The limitations of the basic data and the assumptions that have been made in constructing them are fully set out. The editors and authors must be congratulated on their industry and ingenuity, and the publishers on the technical excellence of the presentation.

Collecting, Preserving and Studying Insects

By Harold Oldroyd. Pp. 327+15 plates. (London: Hutchinson and Co. (Publishers), Ltd., 1958.) 25*s*. net.

ENTOMOLOGISTS need a work bringing together techniques of collecting and preserving insects, and this book will fully satisfy them. Collecting should not be an end in itself, but a means of getting to know insects, the first step towards studying their lives and activities. As the applied entomologist knows too well, our knowledge is still pitifully small, and it is to be hoped that this book will succeed in one of its objects, the stimulation of more voyages of discovery.

Its first chapter, "Where to Look", is followed by an account of the important business of first catching your insect, describing the various types of net, light traps and other devices, and there is a section on rearing and breeding. Methods of killing, temporary preservation, and preparation of permanent mounts are explained, together with the examination of specimens, the use and care of microscopes and the photography of live as well as dead insects.

There is a section on identification, a key to the orders of insects, and a general account of the features of each order with appropriate collecting and preservation methods. Also included are chapters on classification and nomenclature, the preparation of papers and illustrations for publication, with a guide to the specialist books and journals. Useful appendixes include a glossary of technical terms, reagents and formulæ and addresses of suppliers. A practical book, well illustrated, simply written and most readable, yet detailed enough to make a permanent work of reference, it will be invaluable alike to beginners and all entomology departments B. D. Moreton

Fruit and Vegetable Preservation Industry in India

(Proceedings of the Symposium held at the C.F.T.R.I., Mysore, on 4th and 5th October 1954.) Pp. xiv+485. (Mysore: Central Food Technological Research Institute, 1956.) Rs. 6; 15*s*.; 2.50 dollars.

THIS book contains a foreword by the Director of the Institute, a list of participants in the symposium, the opening speeches and some 64 papers arranged in eleven sections (covering such varied subjects as raw materials, scientific aspects of preservation, quality control, microbiological problems, additives and preservatives, nutritive value, application of refrigeration, types of containers, plant and equipment, technical information services, etc.). It also reports the final discussion on need for action by the Government in promoting research, the type of research station required and the part the Government should play in establishing factories, together with the recommendations for fostering the industry submitted by the symposium to the Planning Commission and other Government departments.

Few, if any, of the papers contain any original data or observations but some are very useful summaries of existing knowledge. Taken altogether they provide a thorough survey of the state of the development of the fruit and vegetable preservation industry of India, and problems which will have to be faced in its further development. R. G. Tomkins

Physics for Science and Engineering

By Robert L. Weber, Marsh W. White and Kenneth V. Manning. Pp. vii+617. (London: McGraw-Hill Publishing Company, Ltd., 1957.) 60*s*.

IN this very sound introduction to physics, the first eighteen chapters (roughly one-third of the whole book) deal with the important background work of mechanics and the mechanical behaviour of materials, while about the same space is allotted to electricity and magnetism. The authors set out to train the reader in the methodical solution of problems, paying particular attention to units and significant figures, and set a good example in the many worked exercises in the text. Problems, indeed, make up a fair proportion of the short section on heat; while that on light is quite lavishly descriptive, with some excellent pages on spectra, a chapter on colour which is spread with coloured figures in the text, and some good photographs illustrating polarization effects. Sufficient is said about electronics and nuclear physics for the reader to grasp clearly what these subjects are about; but the really thorough spadework has gone into the two major sections of the book, which will repay an equally thorough reading. Because of the emphasis on instruction rather than description, and the type of exercise given, it is possible to place the standard fairly accurately in terms of teaching in Britain. It is about that of the Advanced level of the General Certificate of Education. G. R. Noakes

CHEMICAL ASPECTS OF SELECTIVE TOXICITY*

By Prof. ADRIEN ALBERT
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SELECTIVE toxicity may be defined as the injuring of one kind of cell without injuring some other kind of cell with which the first is in intimate contact[1]. Thus, in agriculture, it is concerned with ridding crops and seeds of noxious insects and fungi, without causing harm to the higher plants. In veterinary and human medicine it is well exemplified by chemotherapy, which safely rids the host of internal parasites. A more delicate form of selective toxicity is met in pharmacodynamics. Here both types of cell are in the one species, and the task of selective toxicity becomes more difficult. This difficulty is intensified by the necessity of exerting a graded response, and of allowing the cells to recover in the course of time. Thus a patient with insomnia can be put to sleep by a drug which acts on the central nervous system, but the nerve cells which have been poisoned (and poisoned to a predetermined degree) must recover in time for the patient to go to his work next morning.

That selectivity is possible seems to rest on two main principles: (*a*) different kinds of cells exhibit very different kinds of distribution phenomena, and (*b*) the anabolic processes of different cells differ widely (catabolic processes appear rather similar). Whereas detailed knowledge of anabolic differences awaits further work in the field of comparative biochemistry, much is already known about differences in distribution.

When a substance is administered, it has to penetrate at least one semi-permeable membrane before it enters into circulation. Sometimes the substance, as administered, is only a 'pro-drug' which has to be broken down to give the true drug. Examples of this kind are phenacetin, chloral hydrate, pentavalent arsenicals and two of the antimalarials: pamaquin and proguanil. But this seems to be a rare phenomenon, and it appears that most substances act in the form in which they are given.

The circulating drug (and by 'drug' is meant any biologically active substance) then takes part in five other phenomena, to various degrees depending on its nature and on the nature of the cell[2]. It can be stored, excreted, or chemically destroyed; it can penetrate another semi-permeable membrane, or combine with its receptor. Storage can be useful, as with the antimalarial mepacrine, which is stored in capillaries from which it is released (under mass action conditions) to maintain a therapeutic level in the bloodstream. Examples are also known where storage is wasteful or the drug is entirely segregated on 'sites of loss'[3]. Chemical destruction (detoxication), usually by primitive (not highly specific) enzymes in microsomes[4], takes place by one of seven or eight standard chemical reactions which increase partition coefficients in favour of water so that the penetration of further membranes is diminished. Excretion is usually by the kidney or bile duct in mammals, and these are so constituted that the chemical changes brought about by detoxication greatly increase the excretability of the drug[5].

If, as seems usually to be necessary, the drug has to penetrate yet other semi-permeable membranes before its meets the receptor, the chances of selective toxicity are heightened. Four different types of membranes are distinguished[6,2]: (*a*) where diffusion is regulated by pore-size, (*b*) where a lipoidal layer causes substances to diffuse at a rate proportional to their lipoid/water partition coefficient and excludes the majority of ions, (*c*) where a lipoid anion (for example, oleate) assists the passage of cations, and (*d*) where specific nutrients, particularly anions, are transported (often enzymatically), utilizing energy obtained from the simultaneous oxidation of (for example) glucose. Mixed types of membrane have also been found.

Bearing in mind the various types of membrane made available by different kinds of cells, and the various rates at which a drug, imprisoned within any pair of these membranes, will be subjected to the processes of storage, destruction and excretion, it is easy to see how specificity can be promoted merely by small changes in the rate or equilibrium constants governing any of these processes. To be added to these factors, which in sum govern the rate at which the drug will reach the receptor, is the affinity which the drug has for the receptor.

Receptors, according to Ehrlich[7], are chemical groups containing, perhaps, less than a dozen atoms, which normally perform one of the metabolic duties of the cell: when blocked by the drug they can no longer function and thus the pharmacological effect occurs. At the present time workers tend to equate 'receptor' with the active group of an enzyme.

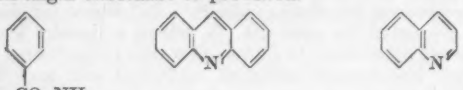
The combination between drug and receptor seems usually to occur by secondary valencies, namely, hydrogen bonds, ionic bonds and multiple van der Waals bonds. Covalent bonds must be rare because such bonds are seldom easily broken at 20°–37° C., whereas most drug-receptor effects can be terminated by washing with saline. Ehrlich was aware of this distinction when he wrote[8]: "If alkaloids, aromatic amines, antipyretics or aniline dyes be introduced into the animal body, it is a very easy matter, by means of water, alcohol or acetone, to remove all these substances quickly and easily from the tissues". This was in 1898, before knowledge of bond-strengths, -types and -distances became as exact as it is to-day[9].

Nevertheless, a few examples are known of the formation of covalent bonds with receptors, mainly by those drugs which can acylate or alkylate (penicillin, the nitrogen-mustards and the phosphorus anti-cholinesterases), but also by a few substances which become chemically incorporated into vital parts of the cell (for example, *p*-aminosalicylic acid into folic acid, and azaguanine into nucleic acid).

Physiological action is highly dependent upon the finest details of chemical structure. If these details are varied ever so slightly, the degree of action is usually radically changed. For example, both the C-methyl-groups in thiamine are essential for its vitamin action. In synthetic drugs, a similar dependence on minute detail is observed. Thus in benzenesulphonamide (I), an amino-group can be inserted in

* Based on a University of London Special Lecture in Pharmacology, given in the London Hospital Medical School on June 9.

three different positions: in two of these it gives rise to an inactive substance, but in the other it gives the highly antibacterial substance sulphanilamide[10]. Again, in acridine (II), an amino-group can be inserted in five different positions: in three of these it gives aminoacidines which are almost inert, but in either of the other two it gives a powerful antibacterial[11]. Once again, in quinoline (III), a hydroxy-group can be inserted in seven different positions: in six of these, completely inert substances are created, but in the remaining position a strong antibacterial and antifungal substance is produced.



(I) (II) (III)

In each of these three examples, it is known why the active isomers are active, and why they alone are the active ones. The activity of the sulphonamides depends on the *para*-isomer being a metabolite analogue for *p*-aminobenzoic acid, to which it shows a close structural resemblance[10]. The activity of the acridines depends upon something quite different: only in the 2- and 5- positions can an amino-group acquire enough resonance stabilization in the cation to produce a highly ionized substance (the antibacterial action of the acridines depends on a high degree of ionization, see below). The activity of the quinolines depends on yet another principle: only in the 8-position can a hydroxy-group collaborate with the ring-nitrogen atom to bind metal cations by that pincers-like process known as chelation, and the antibacterial action of 8-hydroxyquinoline depends upon chelation[12,13].

Since the discovery of the mode of action of sulphonamides, metabolite analogues have received closer investigation and have led to the discovery of many substances which block specific enzymes and hence are of great value to the biochemist. Antivitamins, of similar nature, have contributed usefully to nutritional studies[14]. But in human medicine the most successful antimetabolites are, so far, all connected with pteroylglutamic acid (folic acid). This acid, a vitamin or vitamin-precursor, consists of a pteridine nucleus to which are linked *p*-aminobenzoic acid and glutamic acid. Sulphonamides exert their antibacterial action by preventing the incorporation of *p*-aminobenzoic acid into this substance, whereas *p*-aminosalicylic acid actually becomes incorporated in its place. Some antileukæmic agents of clinical value have been made by substituting amino for hydroxyl in the pteridine ring, and a much used antimalarial (pyrimethamine or 'Daraprim') was evolved as a metabolite analogue of the pteridine portion of folic acid[15]. A new type of synergism has been devised, known as sequential blocking, where metabolite analogues of two stages of the folic acid cycle are used together.

The great success of these various anti-folic acid drugs depends on a singular set of coincidences: man does not require *p*-aminobenzoic acid but must absorb folic acid from his diet, and pathogens require *p*-aminobenzoic acid to form their own folic acid, but cannot absorb it if supplied (it is possible, of course, that their folic acid is slightly different from ours). In searching for useful analogues of other metabolites, these facts have to be borne in mind.

The majority of biologically active substances are capable of ionizing to different degrees at different *p*H values; also the extent of their ionization can be controlled by small alterations in the chemical structure. This variability in ionization is important because an ion and its corresponding neutral molecule undergo different chemical reactions, penetrate membranes differently, and become adsorbed on different types of substance[16]. Because the combination between ions and receptors must be reversible (from the very nature of the bond) the degree of ionization under the conditions of the experiment is all-important for effecting combination. This does not mean, however, that complete ionization is always an advantage, because foreign ions do not readily penetrate membranes; also, a few examples are known where a pharmacological effect seems to be brought about by the neutral molecule[1,2].

Only two factors affect the degree of ionization of a substance: the ionization constant, and the *p*H at which the experiment is conducted. Given these, the percentage ionization can at once be read from a table[1].

The acridine antibacterials are the most studied example of positive correlation between ionization and biological activity[11]. It was shown, using 107 variously substituted acridines, that at least 50 per cent of the substance must be present as cation to give a significant bacteriostatic effect. This work produced the antibacterial substance, aminacrine, which is now included in the British Pharmacopœia.

Metal-binding substances are of two types, those like 8-hydroxyquinoline (oxine) which bind by chelation (see above), and those like dimethyldithiocarbamic acid which bind without the aid of chelation (these are usually sulphur-derivatives). Biologically, both types act similarly, provided the stability constants are high enough. Stability constants, which are derived from mass-action equations, form a reliable indication of the avidity with which a metal is held by a particular binding agent. Contrary to general belief, the various binding agents show very little differences in their preference for the different metals.

Some metal-binding agents are used in medicine as antidotes to poisoning because they withdraw toxic metals and metalloids. Examples of this kind are dimercaprol (arsenic, antimony and gold), and ethylenediamine tetracetic acid (lead). Others act by forming toxic complexes with such metals of variable valency as are present in the medium. Such a substance is oxine, which does not injure bacteria in the absence of iron[13]. Toxic complexes of this kind appear to initiate oxidative chain reactions, and death occurs very rapidly. Thus, the chelation of a metal of variable valency does not necessarily decrease its biological action, but often increases it. Measurements of oxidation-reduction potentials now in hand should give a better guide to the choice of inactivators.

Several much-used drugs, such as the salicylates, aureomycin, and isoniazide, bind metals at least as strongly as do the amino-acids, and hence could well act by chelation. Some convincing evidence concerning isoniazide has already been obtained. Chelating agents are widely used in crop-protection, for example dimethyldithiocarbamic acid and its derivates, the mode of action of which resembles that of oxine[17].

Toxicity can be brought about in other ways than through covalent bonding, metabolite analogues, ionization and metal-binding. The rupture of cell-membranes, as affected by phenols, quaternary

lipophiles and polymixin, has been reviewed recently[18] and shows some selective effects.

The class of substances known as 'depressants' is unique in that the toxic effect is dependent on chemical structure only to the limited degree necessary to make the substance lipophilic enough to reach the central nervous system. Thus the inert gas, xenon, has been successfully used as a general anæsthetic in man[19]. The lack of a dipole moment indicates that this gas acts in the bulk phase rather than by adsorption at a surface. Thus it seems to be merely a diluent separating biochemical components which should react together. The mode of action of all volatile anæsthetics is almost certainly the same as that of xenon, because they all act at those concentrations which produce a standard thermodynamic activity. This was first demonstrated by Ferguson[20], and the anæsthetic activity of xenon was predicted from Ferguson's principle[21], and verified.

This presentation of the phenomena of selective toxicity has necessarily been from the chemical angle. It is put forward in the hope of supplying biologists with a framework which may help to classify results and to suggest new, and often more decisive, experiments.

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FORMATION OF A HELICAL STEROID COMPLEX

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THE purpose of this communication is to describe the formation of a helical complex of macromolecular dimensions from the bile acid steroid, sodium deoxycholate.

The reaction was first observed when an aqueous solution of sodium deoxycholate was buffered with glycylglycine. Within a few minutes of making up a solution containing 0·1 *M* sodium deoxycholate and 0·1 *M* glycylglycine, unusual changes occur in the physical properties of the solution. There is a large increase of viscosity, and the solution can be drawn out into very long glassy fibres which are stable and dry into clear brittle rods. Soon the solution can almost be lifted clear of its container as a cohesive jelly-like aggregate. It has a mucous-like stickiness when handled. If the solution is allowed to stand, it will eventually form a clear gel which has considerable rigidity.

The complex can be formed most simply by adding acid to an aqueous solution of sodium deoxycholate. The solution becomes very viscous when the *p*H falls below about 6·8 (about 0·2 equivalent of acid). Addition of much larger amounts of acid causes a precipitate of the insoluble deoxycholic acid to form, but there is a range of *p*H and concentration in which the solution is clear and viscous. High ionic strength evidently assists the complex to remain in solution, and solutions of less than 0·01 *M* are always turbid in this *p*H range unless salt is added. The formation of the complex is immediately reversed on raising the *p*H.

By working with these dilute solutions, the phenomenon can be studied in a viscometer. In an aqueous solution containing 0·01 *M* sodium deoxycholate, 0·01 *M* glycylglycine and 0·04 *M* sodium chloride, a maximum viscosity is reached in about 15 min. The macromolecular dimensions of the complex can be demonstrated in the analytical ultracentrifuge, which shows a rapidly migrating peak with a sedimentation constant of 12–15 S. The solutions which have been described as clear always exhibit the Tyndall effect to some extent.

We should explain that we have had some difficulty in finding an adequate terminology for describing these phenomena. The above observations are characteristic of the formation of an elongated polymer. There is no reason to believe, however, that any covalent bonds are formed in this system, and so we have preferred to use the word 'complex'. Although the particles of the complex are of macromolecular size, we have avoided calling them macromolecules.

X-Ray Diffraction Studies

To study the internal structure of the complex, X-ray diffraction studies were carried out on air-dried fibres, some of which contained glycylglycine in addition to the steroid. The fibres are usually glassy clear and brittle, and have weak negative birefringence (− 0·002). The diffraction patterns are unusually detailed. Two characteristic types of diffraction pattern are reproduced in Figs. 1 and 2. Fig. 1 was obtained from a fibre with a glycylglycine : deoxycholate mole ratio of 0·5 : 1. It can be seen that the more intense layer lines are clearly resolved into a series of spots. Heavier exposures show that the weaker lines are also made up of a series of closely spaced diffraction spots. The equatorial spacings correspond to a hexagonal lattice with $a = 39{\cdot}2$ A. The first layer line spacing is 49·2 A.

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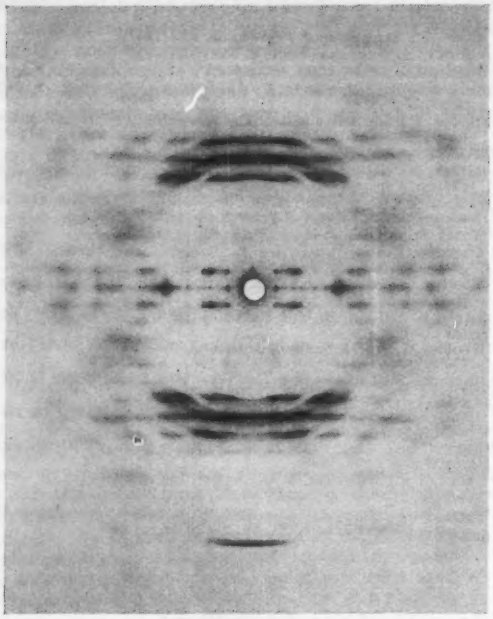

Fig. 1. X-ray diffraction photograph of sodium deoxycholate complex containing 0·5 mole glycylglycine per mole deoxycholate. Fibre axis is vertical, copper $K\alpha$ radiation

Fig. 2 shows a diffraction photograph obtained from a fibre with a glycylglycine : deoxycholate mole ratio of 3 : 1. It can be seen that the diffracted intensity still lies on a series of layer lines with an intensity distribution very similar to that seen in Fig. 1, but instead of resolved spots, a series of continuous streaks appear. This is the continuous Fourier transform and probably arises because individual diffracting units have assumed random angular orientation about the fibre axis and have also undergone some random lateral displacement. The diffraction photograph of a fibre obtained by adding hydrochloric acid to sodium deoxycholate is very similar to Fig. 1, except for changes in the lattice spacings and some intensity alterations described below. Fibre photographs have also been obtained when other amino-acids are used as buffering agents instead of glycylglycine. All these diffraction patterns show similar distributions of intensity, indicating a similar continuous transform which is sampled in different ways, corresponding to different types of crystallinity. For example, in the presence of alanine, the equatorial spacings no longer correspond to a hexagonal unit cell, but indicate another kind of packing. When there is more of the amino-acid component relative to the steroid, the continuous transform occurs more frequently and the structure is less crystalline.

Another important feature of the diffraction pattern is the occurrence of non-integral layer line spacings. Thus, the first layer line in Fig. 1 occurs at 49·2 A. The group of three intense layer lines near the meridian occurs at spacings of 7·65, 6·6 and 5·8 A. These are not integral divisors of 49·2 A. The reason for this discrepancy can be seen more clearly in Fig. 2, where the arrow points to what would normally be called the fourth layer line. It is split into two layer lines which occur at slightly different spacings. Because of this feature[1], and the open areas which occur on the meridian of the diffraction photograph, it is clear that the molecular complex has the form of a helix with a non-integral number of residues per turn[2].

In order to determine the fundamental screw operation which must be carried out to build up the helix from an asymmetric unit, it is necessary to find a true meridional reflexion which represents the translation of the asymmetric unit along the fibre axis. At first it was thought that the 6·6 A. layer line was meridional, but precession camera photographs have shown this to be less likely, and a more probable choice is the layer line which occurs at 2·29 A.

Using this interpretation of the diffraction pattern means that the 6·6 A. layer line represents the pitch of the primitive helix. Hence, we can describe the fundamental screw operation needed to generate the helix as a translation of 2·29 A. and a rotation of $\frac{2 \cdot 29}{6 \cdot 6} \times 360° = 125°$.

An air-dried fibre of the steroid helix formed by adding only hydrochloric acid has a density of 1·19 and a hexagonal a-axis of 36·2 A. (Table 1). These figures can be interpreted as indicating that there are four steroid molecules and approximately twelve water molecules in the asymmetric unit.

The diameter of the helical complex varies with the amount of glycylglycine that is added. Table 1 lists the a-axis of the hexagonal lattice for fibres drawn from solutions with varying mole ratios. Since the complex is helical, the a-axis represents the distance between neighbouring complexes and is therefore its approximate diameter. Table 1 shows

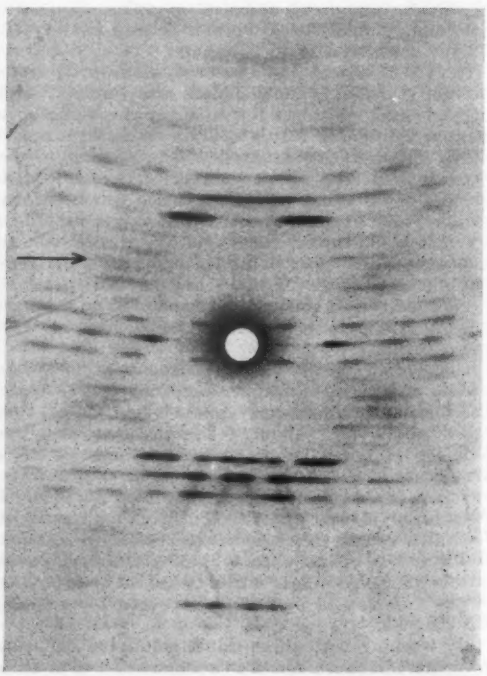

Fig. 2. Diffraction photograph of complex with mole ratio glycylglycine : sodium deoxycholate of 3 : 1. The fibre axis is vertical but tipped slightly. The arrow points to the splitting of the fourth layer line. Copper $K\alpha$ radiation

Table 1. *a*-AXIS OF HEXAGONAL LATTICE FOR COMPLEXES WITH VARYING AMOUNTS OF ADDED GLYCYLGLYCINE

Mole ratio glycylglycine : sodium deoxycholate	*a* (A.)
0 : 1	36·2
0·5 : 1	39·2
1·5 : 1	40·5
3 : 1	49·1

the composition of the solutions from which the fibres were drawn. Preliminary analyses of fibres have shown that they have the same mole ratio as the parent solutions. Addition of increasing quantities of glycylglycine causes a steady increase of the *a*-axis. The changes show that the excess glycylglycine is incorporated into the lattice. In all the diffraction photographs, the first layer line spacing remains approximately constant at 49·2 A., and the diffraction pattern does not change very much.

On comparing two diffraction patterns with differing amounts of glycylglycine, it was observed that the first layer line at 49·2 A. was more intense near the meridian in the fibre with the large amount of glycylglycine. The increase in intensity occurred at a radius $R = 0{\cdot}038$ reciprocal units from the meridian. In helical diffraction patterns, the relative intensity on the various layer lines is determined by the magnitude of the nth order Bessel functions $\sum_j J_n(2\pi r_j R)$, where r_j is the radius of the j^{th} atom, R is the radius in reciprocal space, and n is determined by a selection rule[3].

If the 2·29 A. layer line is a true meridional reflexion, the selection rule states that the first layer line is composed chiefly of third-order Bessel functions. This may be used to obtain an approximate value for the radius r of the additional glycylglycine. This is done by equating the argument of the third-order Bessel function at its first maximum to $2\pi Rr$, using $R = 0{\cdot}038$. The answer obtained in this way is 17·6 A. This corresponds closely to the radius of the complex and suggests that at least some of the glycylglycine is packed around the outside of the helical steroid complex. It is quite likely that this explains the occurrence of the continuous transform shown in Fig. 2, since it is more common when there is a large amount of glycylglycine. This component on the outside of the complex may hinder interactions between steroid molecules in adjacent helices and thereby reduce the crystallinity.

It is likely that in the fibres the steroid molecules are built into the helical framework, and at least part of the other component is attached to the outside. This interpretation is supported by the observation that the helical pitch of the complex is independent of the amount of glycylglycine (or of any of the other amino-acids examined). It remains to be seen whether the helical aggregate of deoxycholate molecules will surround itself with other molecules which are incorporated into the lattice as are the glycylglycine residues.

Chemical Properties

Formation of the helical complex is induced by adding protons in the form of hydrochloric acid to an aqueous solution of sodium deoxycholate. This has a considerable influence on the titration curve of deoxycholic acid (3α,12α-dihydroxycholanic acid) as compared to a closely related substance such as cholic acid (3,7α,12α-trihydroxycholanic acid). Cholic acid has a pK at 5·5 which corresponds to the titration of the carboxyl group located at the end of the hydrocarbon chain attached to the steroid nucleus. However, under identical conditions (0·1 M concentration), deoxycholic acid has a pK at 6·6 for the same carboxyl group. The loss of one hydroxyl group located on the steroid nucleus is inadequate to account for the large shift in the pK for this group. The explanation is undoubtedly associated with the formation of the helical complex in solution. The deoxycholate ion accepts a proton more readily than the cholate ion in association with its formation into a macromolecular complex. A somewhat similar example of a shift in the pK of an ionizable group is seen with polyadenylic acid, where the molecule can be induced to form a macromolecular helix if a proton is added to the adenine residue[3]. The pK of adenine has shifted by more than one pK unit with its organization into a helical form.

In the deoxycholate complex, it is quite possible that the added proton on the carboxyl group is used in hydrogen bonding to hold together some of the steroid residues. Whether or not all the steroid residues in the complex require a proton remains to be established.

One of the most striking features in the formation of these complexes is the enormous rise in viscosity and eventual gel formation. This must be due to the formation of helical aggregates of considerable length. A helical arrangement of sub-units is, of course, well suited to the formation of very long aggregates, as it can be elongated indefinitely. The extreme length of the particles is probably responsible for the perfection of the diffraction pattern.

A few closely related steroids have been tested to see if they would form similar helical complexes. These include sodium cholate, sodium glycocholate, sodium taurocholate, sodium lithocholate and sodium apocholate. The results were negative in all cases. The formation of the complex is thus highly specific to the geometry of the deoxycholate molecule and can be inhibited by alteration of the hydroxyl positions or by a slight modification of the steroid ring system.

Relation to the Choleic Acids

Wieland and Sorge[4] discovered in 1916 another highly specific interaction in which deoxycholic acid is involved: the formation of the choleic acids. These are crystalline solids, obtained from non-aqueous solutions, in which deoxycholic acid occurs in conjunction with a large variety of organic compounds in definite molecular proportions. The choleic acids formed with long-chain fatty acids have been closely examined and a crystallographic study of their structures was begun by Kratky and his collaborators more than twenty years ago[5]. The only other steroids known to exhibit similar properties are apocholic acid and 'β'-apocholic acid[6], compounds identical with deoxycholic acid except for an unreactive double bond in the steroid ring system.

We are thus confronted by two highly specific interactions in which the deoxycholate residue takes part. It may be helpful to summarize a few profound differences between the two kinds of interaction. The formation of choleic acids is described as an interaction between two types of compound; the complex we have described here forms alone in aqueous solution, and the primary effect is akin to a polymerization. Although the presence of other materials affects the crystallinity and the crystalline lattice of the fibre, this may be regarded as a secondary effect. Indeed, in experiments we have so

far carried out, attempting to demonstrate interactions in solution between amino-acids and the complex, we have failed to find any effect. The choleic acids are usually observed in the solid state; in solution they appear only to influence the solubility. This contrasts markedly with the viscosity changes and evidence for formation of large aggregates in solutions of the deoxycholate complex. Finally, we may mention the difference in dimensions between the two. The fatty acid choleic acids crystallize in an orthorhombic unit cell, $P2_12_12$, $a = 25{\cdot}8$ A., $b = 13{\cdot}5$ A., $c = 7{\cdot}2$ A.[8]. This bears no obvious relation to the dimensions of the helix in which the complex forms.

Nevertheless, the two effects probably have some factors in common. Bernal, Crowfoot and Fankuchen[7] have noted that a hydroxyl group in the 3α position of the steroid nucleus is in a specially favourable position for hydrogen bonding. Hydrogen bonding is probably an important force in both effects, and in many other kinds of steroid interaction. What special feature of the deoxycholate molecule confers its unique properties we do not yet know.

We would like to acknowledge assistance and helpful discussion by Mr. K. Shine and Dr. D. F. Bradley, and to thank Dr. Elwood Titus for preparing a sample of apocholic acid.

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THE LAST MINUTES OF SATELLITE 1957β (*SPUTNIK 2*)

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SPUTNIK 2 made its final descent through the atmosphere between 01.50 and 02.00 hr. U.T. on April 14, 1958, on a line running between New York and the mouth of the Amazon. Though the satellite entered the Earth's shadow before reaching New York, it had by then become self-luminous and a number of valuable observations were made in the Atlantic and Caribbean from ships which happened to be near its track. Observations received from British ships are plotted in Fig. 1, together with two from Trinidad and three 'Moonwatch' observations from near New York.

For the purposes of Fig. 1, the height of the satellite was assumed to vary linearly with latitude between 70 nautical miles at 40° N. and 40 nautical miles at 10° N. This assumption is arbitrary and over-simple, but it seems to fit the facts reasonably well. If these heights were correct, the satellite, or what remained of it, would probably have come to earth just north of the equator. In Fig. 1 the estimated track of the satellite is superposed, assuming the inclination of the orbit to the equator is 65°. Estimates of the time are also given, as ringed numbers.

The appearance of the satellite became more spectacular as it proceeded farther south, and the reports from the different ships agree well, except on the question of colour. At latitude 30° N.

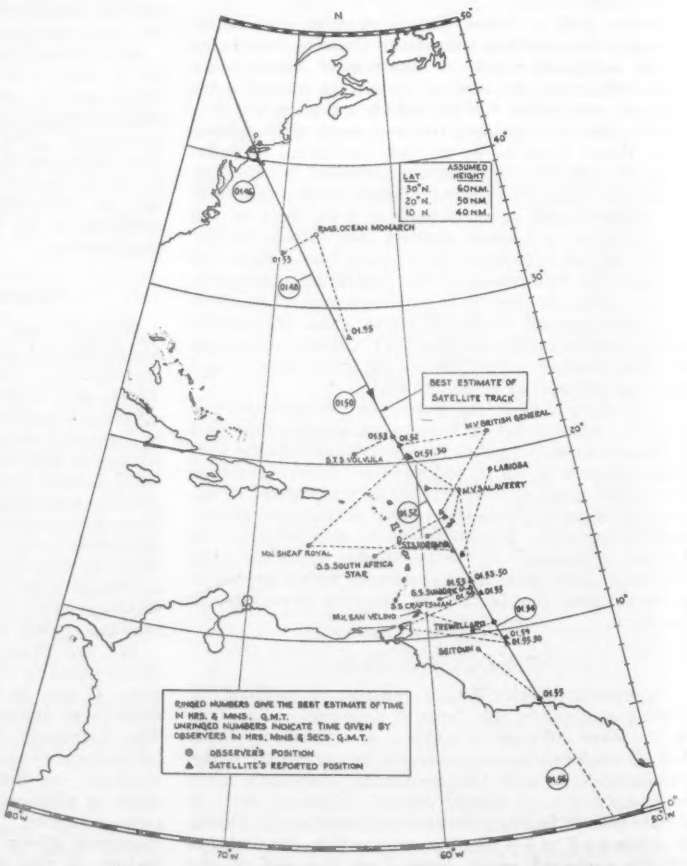

Fig. 1. The last minutes of *Sputnik* 2, April 14, 1958

the satellite was glowing a dull orange, but had developed no tail. At latitudes south of 20° N. it had a long tail alive with sparks, "like those thrown off from a grinding wheel". The sparks were often seen to fall away from the tail and then soon ceased to glow. Estimates of the length of the tail vary between 30 and 90 nautical miles, with a mean of about 50 nautical miles. The estimates of the brightness suggest that when the satellite was between latitudes 20° N. and 15° N. its stellar magnitude was roughly −5 at a distance of 100 nautical miles. The satellite seems to have taken on almost every colour of the spectrum at some time during its descent, and it is only possible to list the colours reported, which were: orange, white, yellow, greenish-blue and red; yellow and orange; orange, silver, blue and green; yellowish-white; blue and red; white to greenish-blue; red and white; green and red; red, orange and white; white; and "a rather sulky crimson".

We wish to thank the captains and crews of the ships from which observations were made. We also thank Mr. D. H. Sadler, superintendent of H.M. Nautical Almanac Office, who arranged for a general call to shipping to be made and sent us the reports received.

OBITUARIES

Dr. W. S. Bauld

THE tragic death of Dr. William St. Clair Bauld, his wife Marion, and two of their children on July 20 in a car accident in Canada profoundly shocked and saddened their many close friends in Great Britain.

Bauld was born at Wolfville, Nova Scotia, in 1919. In 1939 he graduated B.A. with honours in chemistry from Acadia University and then proceeded to Dalhousie University, where he was awarded the degree of M.Sc. in 1941 for research on the œstrogens carried out under the direction of the late Dr. R. D. H. Heard. During 1941–43 Bauld served in the Royal Canadian Artillery and was at first on the teaching staff of the Army Radar School, then becoming overseas liaison officer for the Canadian National Research Council and finally officer-in-charge of inspection of all radar equipment made in Canada. He retired from the Canadian Army with the rank of major.

After the War, Bauld decided to study medicine and enrolled at McGill University. In 1949 he graduated M.D., C.M. I first met Bauld in Montreal a year before his graduation from McGill and was greatly impressed by his personality and by his evident wish to resume research on the œstrogenic hormone. This meeting led to Bauld's appointment to a lectureship in the Department of Biochemistry in the University of Edinburgh in October 1949.

At Edinburgh, Bauld was outstandingly successful both as a teacher and as a research worker. He was a lucid and inspiring lecturer who was very popular with, and respected by, those he taught. His elegant work on the quantitative determination of œstriol, œstrone and œstradiol-17β in urine gained him international recognition as an authority in the field of the œstrogenic hormone, and in 1953 he was awarded the degree of Ph.D. for a thesis embodying the results of this work. A chance observation made by Bauld in the course of this work led to the subsequent isolation by him and me of 16-*epi*œstriol from the urine of pregnant women.

Bauld's contributions to the Edinburgh Medical School were not merely those of a first-class teacher and research worker. His capacity for working hard and playing hard and his infectious enthusiasm for everything he did acted as a tonic to all who came in contact with him. He was greatly missed when he returned to Montreal in 1954 to join the staff of the Montreal General Hospital as an assistant in the Department of Metabolism and Toxicology.

Bauld's progress after his return to Montreal was spectacular. At the time of his death, less than four years later, he had become associate director of the Department of Metabolism and Toxicology, assistant director of the Montreal General Hospital McGill University Clinic and assistant professor of medicine at McGill University, and had become recognized as a chemical pathologist of the highest rank.

The Baulds' home, whether in Edinburgh or in Montreal, was a particularly happy one where visitors were always warmly welcomed. In both cities the Baulds had many friends who loved and respected them and who will miss them sorely.

G. F. MARRIAN

Prof. G. M. Wishart

PROF. G. M. WISHART died on July 18 in his sixty-third year after a short illness. Since 1947 Wishart had devoted himself to administration, being director of postgraduate medical education and dean of the Medical Faculty of the University of Glasgow. Previously Wishart had held the Gardiner chair of physiological chemistry: the later period, given over to administration, has tended to obscure the merit of the scientific work in the earlier years.

The medical profession of to-day accepts with good grace the importance of the basic sciences in the theory and practice of medicine: it was not always so, and men such as Wishart had more than a little to do with this change of heart.

Wishart was instinctively at home in the physical sciences: his first degree was in science; he qualified afterwards in medicine. In the 1920's, biochemistry was applying accurate chemical techniques to biological problems. Wishart studied in Lund under Thunberg and this gave him an abiding interest in the factors governing enzyme action. Hydrogen ion concentration had to be measured accurately because of its importance in biological systems: Wishart designed a glass electrode to measure *p*H. He early appreciated the potentialities of the thermionic valve and designed a most sensitive electronic oscillometer to measure blood pressure in man.

About this same time the application of indirect calorimetry to man had become well established. It was now possible to measure with accuracy the factors, internal and external, influencing the expenditure of energy in human beings. Wishart made a quite exhaustive study of basal metabolism and

published a series of papers with a bearing on the metabolic cost of various types of muscular work. Wishart's familiarity with the physical approach to biological problems found expression in 1931 in the publication of a most useful small book, "Groundwork of Biophysics". Yet he did not abandon his interest in more conventional biochemical studies. He took an active part in the work of the Hannah Dairy Research Institute at Ayr and spent several long vacations working in the laboratories there.

During most of this period of fruitful activity, Wishart was Grieve lecturer in physiological chemistry in Glasgow. In 1935 he was elected to the Gardiner chair, and then teaching and administration began to take their toll of his time. All Wishart's work, scientific, academic and administrative, was characterized by meticulous accuracy and by a scrupulously fair presentation of his views. No one better served his University as research worker, teacher and administrator. R. C. Garry

NEWS and VIEWS

International Co-operation and Geophysical Research

At the recent International Geophysical Year meeting in Moscow, the following resolution was accepted: "The C.S.A.G.I. [Comité Spécial de l'Année Géophysique Internationale] endorses the A.C.I.G.Y. [Advisory Council of the International Geophysical Year] recommendation that observational and data-collecting activities in the geophysical and related sciences be conducted during 1959 on the same general plan as in 1957–58 under the direction of the C.S.A.G.I. or the C.U.R.A.G.I. [Comité d'exploitation et utilization des résultats de l'Année Géophysique Internationale] as far as practicable and at such levels and in such fields as may be determined by each participating committee. The name International Geophysical Co-operation 1959 is suggested for this period". In accordance with earlier decisions, the International Geophysical Year as such will cease at the end of 1958. It was agreed, however, that international co-operation in geophysical research shall continue in so far as each nation finds it practical, and it is left to each nation to decide in which disciplines it shall continue to make observations as during 1957–58 and whether its activity shall be on a higher or lower or at the same level as during 1957–58. The Comité d'exploitation et utilization des résultats de l'Année Géophysique Internationale is a body which will take over from the Comité Spécial de l'Année Géophysique Internationale the work of ensuring international co-operation, and in particular the utilization of the International Geophysical Year results.

California Institute of Technology : Prof. Linus Pauling, For.Mem.R.S.

The resignation of Prof. Linus Pauling as chairman of the Division of Chemistry and Chemical Engineering at the California Institute of Technology is of interest to chemists all over the world. For there can scarcely be any chemist anywhere better known than he. In his books, of which "The Nature of the Chemical Bond" will always remain a classic, and in his 300 research papers, Prof. Pauling has done more than any other person to apply the ideas of the quantum theory to the study of molecular structure. During his tenure of office, the Gates and Crellin Laboratories at 'Caltech' have achieved an almost unique reputation. It was entirely right that he should be elected a Foreign Member of the Royal Society in 1948, and receive the Nobel Prize in 1954.

True to the fate of most pioneers, Prof. Pauling has frequently been at the centre of some kind of controversy. Many people will recall the decision made in the U.S.S.R. some years ago to the effect that his theory of resonance in molecules should be rejected on political and philosophical grounds. Others will think of his difficulties in obtaining a passport from the United States, as a result of the strong opinions which he has courageously refused to disguise. But everyone will be glad that his resignation as chairman is not to imply any diminution of his research interests, for Prof. Pauling will continue in his post as professor of chemistry at 'Caltech'. During the past few years, Prof. Pauling has undertaken fundamental studies of protein structure which are of the highest importance and merit, and show promise of leading to an understanding of the molecular chemistry of such matters as mental disease. In this field his intimate knowledge of molecular geometry and crystal architecture is already showing its tremendous importance. Physicists, chemists and all those who appreciate his warm humanity will wish him well in his newly acquired freedom.

Prof. E. H. Swift

Prof. Ernest H. Swift, who is to succeed Prof. Pauling as chairman of the Division of Chemistry and Chemical Engineering at the California Institute of Technology, graduated from the University of Virginia in 1918. He joined the staff of the California Institute of Technology in 1920 and was appointed professor of analytical chemistry in 1943. As an official investigator for the U.S. Office of Scientific Research and Development during the Second World War, Prof. Swift worked on problems related to the identification of chemical warfare agents and their detection in the field. More recently he has worked on the development of coulometric analysis and is a recognized authority in this field. Prof. Swift is the author of the well-known text-books, "A System of Chemical Analysis for the Common Elements" and "Introductory Quantitative Analysis", and in 1955 he received the Fisher Award of 1,000 dollars given annually in recognition of "outstanding contributions to the science of analytical chemistry, pure or applied, in the United States or Canada".

Botany at Aberystwyth : Prof. L. Newton

Prof. Lily Newton, who is retiring from the Chair of Botany at the University College of Wales, Aberystwyth, began her career as assistant lecturer in the Botany Department, University of Bristol, and in 1920 became lecturer in botany at Birkbeck College, London, under Dame Helen Gwynne-Vaughan. She afterwards worked at the Imperial College of Science and Technology under Prof. V. H. Blackman and her special interest in algæ led her to the position of research worker in the British Museum (Natural History), where she devoted herself to the publication

of a comprehensive handbook of British seaweeds. This work was continued after her marriage to Mr. W. C. F. Newton, who was cytologist at the John Innes Horticultural Institution. Following the untimely death of Mr. Newton in 1927, she became lecturer in botany at Aberystwyth and was appointed to the chair in 1930. She was president of Section K of the British Association in 1949, president of the British Phycological Society (1955–57), and while still in charge of the Department of Botany, held the offices of vice-principal and acting principal of the University College of Wales. Prof. Newton has had a distinguished career at Aberystwyth, where she continued the tradition for research on algæ established by the late Prof. Lloyd-Williams. Recently she has developed a fine botanical garden on the new College site. This will be invaluable when the new Department of Botany, which she has also planned, is completed.

Prof. P. F. Wareing

Dr. P. F. Wareing, senior lecturer in the Department of Botany of the University of Manchester, has been appointed to succeed Prof. Newton at Aberystwyth. Dr. Wareing was educated at Birkbeck College and Chelsea Polytechnic, London, while working as a Civil servant, and graduated with honours in botany in 1936. After service as a tele-communications officer during the Second World War, he was appointed assistant lecturer and later lecturer in the Department of Botany at Bedford College, London. In 1950 he moved to the University of Manchester, where he was appointed senior lecturer in 1956. Since 1947 Dr. Wareing has contributed to many important problems in the field of developmental physiology and in particular on the photo-periodic and chemical control of various growth processes. For this work he was awarded the degree of D.Sc.

Psychology at The Queen's University, Belfast: Prof. G. Seth

Dr. George Seth, who has been appointed to the newly created chair of psychology at The Queen's University, Belfast, had already built up there a small but very active Department. Its research output during the past few years has been considerable, and its graduates are already making a worth-while contribution to British psychology. Dr. Seth graduated B.Ed. from the University of Edinburgh in 1930, and thus belongs to the golden age of that degree, when Sir Godfrey Thomson and Prof. James Drever, senior, turned out year after year students who went on to distinguish themselves in education and psychology. Dr. Seth is in fact the eleventh such graduate to be appointed to a university chair. Dr. Seth went up to the University of Edinburgh from the Royal High School, and took his M.A. with honours in English literature. He remained on the staff at Edinburgh, carrying out research for the Ph.D. degree. His thesis was published in 1935 as part of the important study, "Speech in Childhood: its Development and Disorders", by George Seth and Douglas Guthrie. From Edinburgh, Dr. Seth went in 1935 to be lecturer in the Department of Education, University College, Cardiff, where he remained until 1946. In addition to his teaching work, he was psychologist in the Cardiff Child Guidance Clinic, and during 1941–45 psychologist-in-charge of the Psychological Service for Difficult Children (Government Education Scheme) under the Welsh Board of Health. In 1946 he went to take charge of the newly founded Department of Psychology at Belfast. There he has built up a well-balanced teaching and research programme, which has moved out from its beginnings in the vicinity of education to cover the whole psychological field from the experimental to the social boundaries, with applied work in the industrial and clinical as well as the educational fields. The newly created chair does no more than recognize in a fitting way the existence at Belfast of a Department of Psychology well able to hold its own with its older counterparts anywhere in Great Britain.

Control of Research Programmes in the Department of Scientific and Industrial Research

The Council for Scientific and Industrial Research has announced a change in organization affecting the Department of Scientific and Industrial Research laboratories: small steering committees are being set up to bear responsibility for the research programmes at the new Warren Spring Laboratory, at Stevenage, and at the recently renamed National Chemical Laboratory, at Teddington (*Nature*, 182, 156, 225; 1958). Formerly research boards, which the steering committees now replace, were responsible to the Research Council, but there was not necessarily any common membership. Under the new arrangement the steering committees are full committees of the Research Council and there will be a direct link between the two bodies, because the chairmen of the committees are members of the Council. In addition to the chairman there will be four members of each committee: two from industry with experience in research management, the secretary of the Department of Scientific and Industrial Research, and the director of the laboratory concerned. The industrial members of the Warren Spring Laboratory steering committee are Dr. R. Holroyd (deputy chairman of Imperial Chemical Industries, Ltd.) and Mr. D. A. Oliver (director of research of the B.S.A. Group Research Centre). The chairman is Sir Harry Jephcott, who is chairman of the Research Council and chairman of Glaxo Laboratories, Ltd. The industrial members of the National Chemical Laboratory steering committee, which will assume responsibility from October 1, will be Dr. F. Roffey (research and personnel director of the Distillers Co., Ltd.) and Mr. B. Topley (director of development of Albright and Wilson, Ltd.). The chairman will be Prof. C. E. H. Bawn, of the University of Liverpool.

Science Centre Scheme

In a written answer to Lord Bridgeman's request for a statement about the plans for a Science Centre and the reconstruction of the Patent Office, Lord Hailsham said in the House of Lords on July 30 that the Ministry of Works is negotiating for the lease of the site on the South Bank which was designated under the Science Centre scheme for the Patent Office, and it is intended to start building within the next five years. As originally proposed, this building will be designed to accommodate, in addition to the Patent Office, a new National Reference Library of Science and Invention, built up from the existing Patent Office Library. A further review of the original scheme to provide accommodation for the scientific learned societies, at present housed in Burlington House and elsewhere, on a site adjoining that which has now been leased has shown that the needs of the Royal Society and of the other scientific learned societies at present in Burlington House can, for some time to come, be met more satisfactorily in that

neighbourhood. Discussions are at present proceeding between the Ministry of Works and the learned societies, and the Government has decided not to proceed with the Science Centre scheme in its original form.

Book Exports

Replying to a question in the House of Commons on July 28, Mr. Ian Harvey, Joint Under-Secretary of State for Foreign Affairs, said the Government was seeking to negotiate a British book export scheme with Turkey, and this was under consideration by the Turkish Government. Israel at present allocated some 500,000 dollars a year from its foreign exchange resources for the import of books and periodicals and a proportion of this was spent on imports from the United Kingdom. Indonesian imports were limited by fiscal and exchange controls, but Indonesia was able to include requests for technical books in its requirements for supplies from the United Kingdom under the Technical Co-operation Scheme of the Colombo Plan.

Baghdad Pact Nuclear Training Centre

In a written answer to a question in the House of Commons on July 28, Commander Noble, Minister of State, stated that from the establishment of the Baghdad Pact Nuclear Training Centre in Baghdad in January 1957 to date Britain had contributed £71,722, of which £23,131 was for initial equipment and freight, £23,421 for the staff from the United Kingdom and £25,170 was towards the annual running expenses of the Centre, including the cost of certain training facilities in the United Kingdom, and of replacement and supplementary equipment.

Academic Administration

An article in *The Economist* for July 12, entitled "Professors under Pressure", directs attention to the way in which administrative duties interfere with the teaching and research work of professors in large departments which may comprise 200–300 undergraduates, twenty or thirty academic staff and postgraduate students, twenty or more technical and office staff, an annual maintenance budget of perhaps £5,000, and a postal turnover of 4,000–5,000 items a year. The situation is likely to worsen with the increased responsibilities for dealing with new buildings—science blocks, research laboratories, lecture halls and halls of residence—which university expansion must throw on professors over the next ten years. Urging the need for fresh thinking about the organization of the university, both academic and administrative, and for a determined effort to relate the function of a university to its optimum size, and its organization to its function, the article suggests that the head of a large science department should be redesignated 'chairman' and relieved of moral responsibility for teaching and research, the title 'professor' being retained to denote scholarship and research ability.

Protection of Antarctic Fauna

The need for measures to be taken to preserve birds in the areas of the Antarctic now being visited by man was among other subjects discussed at the Eleventh International Conference of the International Committee for Bird Preservation held in Helsinki in June last. It was agreed by the representatives of twenty countries present to urge that the question of the protection of indigenous fauna, and in particular the much threatened endemic bird fauna, be placed on the agenda of the conference on the future status of Antarctica, for which President Eisenhower and the U.S. Department of State are issuing invitations.

Age Structure in the Engineering Industry

A preliminary study of age structure in the engineering industry showed that the age of men working at a job is likely to be determined largely by difficulties inherent in the job. This investigation was conducted in the south-west of England. To support the hypothesis that the nature of the work is a major determinant of the age of those engaged in it, similar investigations have been carried out by K. F. H. Murrell and S. Grew of the Unit for Research on Employment of Older Workers, University of Bristol, in other parts of the country (*Occupational Psychology*, 32, No. 2, April, 1958). A number of firms throughout Great Britain were invited by the Institution of Works Managers to submit nominal rolls of their employees. In all, 25 firms, situated in the South Midlands, Yorkshire and Lancashire, and the London region, sent the information required. The nominal rolls included the age and occupation of each man. Although the firms which participated cannot be regarded as a random sample of firms in the engineering industry, they were sufficiently diverse in size, organization and product to be regarded as a fair cross-section of firms in the industry. In no case was the difference in mean ages of a pair of regions significant at above the 5 per cent level. This indicated that the regional samples were likely to have been drawn from the same population, and suggested that there are probably no important regional differences in the age distribution of the working population in the engineering industry. This supports the general conclusion made from the original survey.

Colonial Development Corporation

The report and accounts of the Colonial Development Corporation for the year ended December 31, 1957 (pp. v+64. London: H.M. Stationery Office, 1958. 4*s*. net), record a net profit of £732,868, compared with £572,809 in 1956, but the net operating profit fell from £371,718 to £227,909. The fall in commodity prices had serious effects, Macalder Nyanza Mines, Ltd. (copper), showing a loss of £207,505. Four projects just coming into production or operation showed losses but should do better on full-scale working: British Honduras Fruit Co., Ltd., Kasungu Tobacco Estates, Vipya Tung Estates, and Nigeria Housing Development Society, Ltd. There are now 76 continuing projects, compared with 66, and three of the ten new projects were on the Corporation's initiative by extension of existing ones; 42 schemes were under investigation at the end of the year and gross new expenditure during the year was £7 million. Commenting on the Overseas Resources Development Act, 1958, which raises the ceiling for the Corporation's borrowing from £100 million to £150 million, the report reiterates that financing of overseas risk-bearing projects solely by repayable loan capital is unsound, and urges as from 1951 a clean start with relief from existing obligations to service capital, and cancellation of equivalent debt to Government, with a note in the accounts recording the writing off of the £8 million. A further reference to the fall in commodity prices emphasizes that this

is bound to involve losses in marginal projects, such as those the Corporation necessarily undertakes, and that pressure on Colonial economies has already adversely affected projects which are not themselves primary producers.

International Council of Scientific Unions

THE Year Book of the International Council of Scientific Unions of 1958 (pp. ii+74. The Hague: International Council of Scientific Unions, 1958) includes a three-page report, from the Secretary-General, for 1956–57, which records the decision to accept an offer of the Netherlands Government, through the Royal Netherlands Academy of Sciences, to provide a permanent home for the secretariat in the former Royal Palace, Noordeinde, The Hague, and transfer was commenced towards the end of the year. The proposal to publish a quarterly review containing descriptive articles of high standard and details of the current activities of the Unions has been approved by the Executive Board, which has also approved the creation of a Special Committee on Antarctic Research to consider further international organization of scientific activity in Antarctica. Active work in the field of biological abstracting has been organized and at the eighth General Assembly of the Council, to be held at Washington during September 26–October 7, the Executive Board will recommend classification of the International Geographical Union as a General Union. The Year Book is also a work of reference on the Council and the Unions, including lists of members of the Bureau, the Executive Board and the Council, joint commissions, special committees and other organs and of officers of the International Scientific Unions (together with an alphabetical list).

South African Journal of Agricultural Science

THE first issue of a new journal devoted to agricultural science in South Africa has recently reached *Nature* office (*South African Journal of Agricultural Science*, 1, No. 1; March 1958. Pp. 108. Pretoria: Government Printer, 1958. 7*s*. 6*d*.). It is evidently designed to cover a wide field, and the six papers in the first issue are concerned with a fungal disease of muskmelon, a disease of citrus caused by mites, the effect on the Argentine ant of application to the soil of chlorinated hydrocarbons, the influence of lime and phosphate on the growth and uptake of blue-bitter lupin, trials of rootstocks for grapefruit, and studies on the biochemistry of cock semen. The papers are in either English or Afrikaans with bilingual titles, and the legends to figures and tables are also in both languages. The summaries are in English, Afrikaans and French. All the papers are of a high standard and the journal is well produced, with some of the plates in colour. This journal will no doubt prove of great value to agricultural scientists in South Africa as a convenient and speedy means of communicating the results of their research.

African Zoological Types

THE South African Museums Association has recently published "A List of Zoological and Botanical Types preserved in Collections in Southern and East Africa" (1: Zoology, Part 1. Pp. v+147. Pretoria: South African Museums Association, 1958. Obtainable from the Director, Transvaal Museum, Pretoria. 7*s*. 6*d*.). Its title is self-explanatory: it includes all the types published in the literature up to the end of 1955 that have been traced. The total number is about 5,000, distributed among nineteen institutions and nine private collections. It is to be hoped that provision has been made for the latter to find their way into public institutions, where their accessibility and preservation can be assured. The list does not contain the types of the Karroo reptiles, as these have already been dealt with by Haughton and Brink. The arrangement of phyla, classes and orders follows that in "The Zoological Record", but for convenience in reference, families, species, subspecies and varieties have been arranged alphabetically.

Upper Atmosphere Research in the United States

IN Upper Atmosphere Research Report No. 32, February 21, 1958, the U.S. Naval Research Laboratory has given a history of its rocket research programme since 1946 (pp. ii+47. Washington, D.C.: Naval Research Laboratory, 1958. Distributed by U.S. Department of Commerce, Office of Technical Services). Some idea of the extent and scope of the work is indicated by a list of more than 300 publications from the Naval Research Laboratory during this period. The report is a summary of the work carried out and the data obtained from 104 rocket flights. In addition to the scientific data obtained, the instrumentation developed has found application to problems other than upper atmosphere research. Measurements have been made involving the atmosphere, ionosphere, solar and stellar radiation, cosmic rays, air-glow of the night sky, and the Earth's magnetic field. The results achieved are impressive in quality and quantity, although measurements of this type have sometimes revealed inconsistencies indicating the need for further study. An important contribution has undoubtedly been the development of techniques of measurement to an advanced stage, giving reliable operation of measuring instruments in the rocket environment. Of the results obtained, a few examples will illustrate the value of the work. It has been shown that the daytime ionosphere appears to remain dense between the E_1 and F_2 regions, in disagreement with theories suggesting that it is stratified; the F_2 region is much more constant in altitude and lower than previously suggested by ground observations. Measurements with mass spectrometers have given information on the positive- and negative-ion composition of the upper atmosphere, negative ions not being detected on the night flight (115 km.) and positive ions not detected on the day flight (131 km.). The ultra-violet spectrum of the Sun has been studied out to 977 A., a bright emission-line spectrum being photographed in the far ultra-violet. In addition, information has been obtained on the emission of X-radiation. Corrections have been made to the solar constant, resulting in the now generally accepted value of 2·0 cal./min./cm.^{2}. In the northern auroral zone a high intensity of relatively low-energy particles has been detected; these are not protons or heavier particles.

Electronic Temperatures of Planetary Nebulae

HENRI ANDRILLAT, of the Observatory at Lyons, has a paper entitled "Les températures électroniques des nébuleuses planétaires" in *Publication de l'Observatoire de Haute-Provence* (3, No. 35; 1957), in which he gives the results of his work on planetary nebulae observable with the 120-cm. telescope at Haute-

Provence. The paper is divided into three parts, the first of which describes theoretical relations between the measurable intensities of the lines and the values of the electronic temperature; and the second deals with electronic temperatures deduced from the intensities of the lines of [O III] measured by the photographic spectrophotometer. Of the two methods mentioned, that using the hydrogen lines allows the extension of the study to fainter nebulae. Twenty-four planetary nebulae were studied and the electronic temperatures obtained ranged between 8,000° and 27,000° K. Comparison of these results with those obtained by others, in particular the photoelectric measurements of Liller and Aller, have led to disagreements which can be explained by taking into consideration the magnitudes of the monochromatic images. From the intensities of hydrogen and helium lines, a correlation is shown to exist between the electronic temperatures and the extent of ionization of the nebula, characterized by the intensity of the helium lines. The third part deals with the continuous spectrum and the Balmer discontinuity of six planetary nebulae, and the experimental results are compared with those of Cillié and of Spitzer and Greenstein. The former give electronic temperatures which are too high, whereas those of Spitzer and Greenstein give temperatures which are too low. Seaton's theory provides results which are in satisfactory agreement, with the exception of N.G.C. 7662, but it is pointed out that his adoption of 13,000° K. for this nebula is inaccurate. It is admitted that, as Seaton has shown (*Mon. Not. Roy. Astro. Soc.*, 114, 154; 1954), it is also possible to compute electronic temperatures starting with the intensities of other forbidden lines.

Space-Group Theory

Of the many X-ray crystallographers who utilize space-group theory in their structure analyses, few have had a systematic training in this theory, and still fewer have read the classical works of Federov, Schoenflies and Barlow in which the 230 space groups are formally derived; most are content to turn to the standard works of reference, such as the "International Tables for X-ray Crystallography", in which the space groups are tabulated without derivation and without emphasis on their interrelationships. In order to meet this difficulty, N. V. Belov published in 1951 (*Trudy Inst. Krist. Acad. Nauk. SSSR*, 6, 25) a 'class-room method' of deriving all the space groups in a systematic manner, based on his teaching experience in the University of Gorkii. This article has now been made available in English in the form of a translation by V. Balashov (*Proc. Leeds Phil. Lit. Soc.*, 8, 1; 1957). Belov's treatment is inspired by the work of Wulff, who directed attention to the fundamental role of planes of symmetry. Starting from this point, Belov derives the 230 space groups, not in the formal sequence of the crystal classes but in an order better adapted to didactic purposes and better suited to bring into prominence the connexions between related groups. The interrelationships of symmetry elements, seemingly so simple, are in fact so subtle that any crystallographer who reads this article is bound to find in it many new ideas and many familiar ideas presented in a new and stimulating guise. The article is an admirable complement to the many other works on space-group theory already available, and its appearance in English translation is most welcome. Offprints of the translation are available at a price of 7*s.* 6*d.* or 1.50 dollars from Austick's Bookshop, 172 Woodhouse Lane, Leeds 2.

Paul Instrument Fund Committee Grants

Awards have been approved as follows: £285 to Dr. J. W. Jeffery, lecturer in physics, Birkbeck College, London, to enable him to carry out crystal structure determination by X-ray diffraction using an instrument for one-dimensional Fourier syntheses employing dekatron counting tubes. £2,000 to Prof. J. D. McGee, professor of instrument technology, Imperial College of Science and Technology, London, to enable him to construct a television system for X-ray image intensification. £11,000 to Dr. V. E. Cosslett, university lecturer in physics, Cambridge, for the further development and improvement of the X-ray microscope: by extending the resolution beyond that of the optical microscope and by attaching an automatic recording mechanism for quantitative analysis of elements. The Paul Instrument Fund Committee, composed of representatives of the Royal Society, the Physical Society, the Institute of Physics and the Institution of Electrical Engineers, was set up in 1945 "to receive applications from British subjects who are research workers in Great Britain for grants for the design, construction and maintenance of novel, unusual or much improved types of physical instruments and apparatus for investigations in pure or applied physical science".

Ramsay Memorial Fellowships Awards

The Ramsay Memorial Fellowships Trustees have awarded fellowships in chemistry for 1958–59 as follows: Mr. G. S. Laurence, a general fellowship at the University of Leeds; a French fellowship to Mme. Mousseron Canet at the Imperial College of Science and Technology, London; a Spanish fellowship to Dr. J. Rodriguez Martinez, at the Atomic Energy Research Establishment, Harwell, and Rothamsted Experimental Station; a United States fellowship to Mr. Phillip G. Thompson at the University of Cambridge. The Trustees have renewed the following fellowships for the same year: Mr. T. E. Peacock (general fellowship) at the University College of North Staffordshire; Dr. D. McK. Wiles (Canadian fellowship) at the University of Leeds; Dr. M. Masui (Japanese fellowship) at University College, London; Mr. J. E. Fergusson (New Zealand fellowship) at University College, London; Mr. P. Arambarri (Spanish fellowship) at Rothamsted Experimental Station; Dr. Diaz Pena (Spanish fellowship) at the University of Reading; Mr. D. Rodriguez (Spanish fellowship) at the University of Sheffield.

Animal Health Trust Awards, 1958–59

The Animal Health Trust has announced the following senior awards for the period 1958–59. *Wellcome Fellowship:* Mrs. H. E. Rose, to investigate the relationship between various members of the Coccidia, using immunological techniques, and to extend the present work on the immune responses of rabbits to *E. stiedae*, to the immune responses, if any, of poultry to their coccidia. This work will be carried out at the Department of Animal Pathology, Cambridge, and afterwards at the Houghton Poultry Research Station, Huntingdonshire. *Research Training Scholarships:* Mr. B. A. Baldwin (Royal Veterinary College, London), to develop methods of assessing the state of consciousness and sensory per-

ception in domestic animals and the physiological aspects of stress associated with the various methods of slaughter of animals; Dr. A. D. Care, to complete his training for a veterinary degree at the Royal (Dick) School of Veterinary Studies, Edinburgh; Mr. A. R. Gray, to study the pathology of virus diseases at the Department of Animal Pathology, Cambridge; Mr. R. F. Sturrock, to study parasitology with special reference to the responses of free-living stages of parasitic nematodes at the Imperial College of Science and Technology, London. Six Evans Final-Year Studentships have also been awarded.

Clayton and Manville Fellowships and Grants, 1958

THE Institution of Mechanical Engineers has made the following awards for special industrial experience, postgraduate studies, or research in mechanical engineering under the terms of the James Clayton Bequest and the Manville Bequest. The total value of the awards is approximately £4,000. *James Clayton Fellowships:* C. R. Evans, for research at the Imperial College of Science and Technology, London, into the stabilization of flames at high speeds; M. M. Gibson, for research in the University of Liverpool, principally to develop a low-turbulence blower-type wind tunnel for the fundamental study of turbulent boundary layers in two-dimensional flow; A. F. Pexton, to continue research at the University of Manchester on heat transfer in boiling liquids. *James Clayton Grants:* Dr. M. C. deMalherbe (Johannesburg, South Africa), to visit the United Kingdom to study production methods and for visits to nuclear energy organizations; D. H. Fleming-Brown (Scotland), to continue studies at Cornell University on reactor containment vessels and on the behaviour of metals at high and low temperatures; Dr. C. F. Kettleborough (Auckland, New Zealand), to visit British and European universities to study teaching methods, content of courses, laboratory techniques, etc.; N. Birch (Bristol), to visit the United States to study methods and organization for the manufacture of prototype and aero-engines; W. H. Emerson, to continue research at King's College, London, on refrigeration; Dr. J. F. Norbury (Runcorn, Cheshire), to attend the annual meeting of the American Society of Mechanical Engineers to present a paper on fluid mechanics, and for visits to certain universities and research centres in the United States; *Manville Fellowship:* P. B. Davies, for research at the University College of Swansea on variable-speed transmission of power.

Commonwealth Universities Congress, 1958

THE eighth quinquennial Congress of the Universities of the Commonwealth will be held in Montreal at McGill University and the University of Montreal during September 1–5. Delegations have been appointed by the 109 member universities of the Association of Universities of the British Commonwealth, and the Congress will be attended by 350 members of the teaching and administrative staffs, including 111 delegates from the United Kingdom. The presidents of twenty-seven United States universities and members of the Administrative Board of the International Association of Universities will attend as guests and observers. The opening address, on "Expanding Education", will be given by Sir Hector Hetherington, principal of the University of Glasgow, and at subsequent sessions selected speakers will open discussions as follows: Dr. L. A. Kimpton (chancellor of the University of Chicago) and Dr. V. C. Fowke (Saskatchewan), "Who should determine University Policy?"; Prof. J. F. Baker (Cambridge) and Dr. L. A. DuBridge (president of the California Institute of Technology), "Engineering Education and its Place in the University"; Lord Adrian (vice-chancellor of the University of Cambridge) and Dr. F. G. Soper (vice-chancellor of the University of Otago), "Medical Education and its Place in the University"; Dr. D. W. Logan (principal of the University of London) and Dr. J. L. Morrill (president of the University of Minnesota), "The Establishment of New Universities". Further information can be obtained from the Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1.

Announcements

DR. S. KRISHNA, scientific adviser in London to the High Commission for India and scientific liaison officer for India, will relinquish his post on August 18. Dr. Krishna's successor has not yet been named; Mr. B. Sen, assistant educational adviser, India House, Aldwych, London, will be temporarily in charge of the department.

THE British Nuclear Energy Conference, set up in 1955, has increased its membership to nine constituent bodies by the addition of the Joint Panel on Nuclear Marine Propulsion. The Panel consists of four bodies—The Institute of Marine Engineers, The Institution of Naval Architects, The Institution of Engineers and Shipbuilders in Scotland and The North East Coast Institution of Engineers and Shipbuilders.

A CONFERENCE on Gas Discharges, organized by the Physical Society, will be held in the Department of Physics, University College of Swansea, during September 17–20. Further details can be obtained from the Physical Society, 1 Lowther Gardens, London, S.W.7.

A CONFERENCE on Cosmic Rays, organized by the Physical Society, will be held at the Durham Colleges in the University of Durham during September 24–25. Inquiries should be addressed to the Physical Society, 1 Lowther Gardens, London, S.W.7.

A SYMPOSIUM on Cottonseed and its By-products will be held at the Regional Research Laboratory, Hyderabad 9, during December 5–7. Further information can be obtained from the Director, Regional Research Laboratory, Hyderabad 9.

THE eleventh Annual Conference on Electrical Techniques in Medicine and Biology will be held in Minneapolis, Minnesota, during November 19–21. It is sponsored by the Institute of Radio Engineers, the American Institute of Electrical Engineers and the Instrument Society of America through their Joint Executive Committee on Medicine and Biology. Two hundred and fifty-word abstracts for short contributed papers offered for inclusion in the programme can be sent by October 1 to Mr. Robert Erskine, Minneapolis Honeywell, 2753 Fourth Ave. South, Minneapolis, Minnesota, from whom further information can be obtained.

ERRATUM. We regret that in the article entitled "The Structure of Research in Britain" in *Nature* of July 26, p. 207, paragraph 4, penultimate sentence, the word 'not' has been omitted; the sentence should read, ". . . it would not appear that Treasury control has been exercised in such a way as to infringe the independence or integrity of science . . ."

THE FIFTEENTH INTERNATIONAL CONGRESS OF ZOOLOGY

IT was a happy choice of the Permanent Committee of International Congresses of Zoology to hold the Fifteenth Congress in London during 1958, the same year as the Darwin–Wallace centenary, and in addition the bicentenary of the publication of Linnæus's "Systema Naturæ", 10th edition, the starting point of modern zoological nomenclature. A total of 1,934 enrolments was received, and although approximately two hundred of these were unable to attend, the result was the biggest attendance of any Zoological Congress since they were started in Paris in 1889. The United States, with more than two hundred enrolments, provided the largest overseas contingent, closely followed by France, and there was a large party from the U.S.S.R.; more than sixty countries of the world were represented. The numbers present were much higher than had been anticipated and threw an extra burden on the officers responsible for making the arrangements for meetings, accommodation, excursions, etc. However, the officers, with H. R. Hewer (secretary-general) and N. D. Riley (registrar), proved equal to any emergency. Registration of members and issue of Congress literature, badges, etc., started at noon on July 14. Each member received a copy of the sixth edition of "The Origin of Species" with a preface by Sir Gavin de Beer; and "Evolution by Natural Selection", comprising Charles Darwin's sketch of 1842, his essay of 1844, an introduction by Sir Francis Darwin (1909), Darwin and Wallace's original communication to the Linnean Society on July 1, 1858, the whole with a foreword by Sir Gavin de Beer.

The inaugural plenary session was held in the Royal Albert Hall, where, in the absence of the honorary president of the Permanent Committee, Prof. M. Caullery, whose death was reported during the Congress, the secretary-general, Prof. Louis Fage, introduced the president of the Fifteenth Congress, Sir Gavin de Beer. In his inaugural address, Sir Gavin referred briefly to the events of the past five years, and in particular to the position of the International Commission for Zoological Nomenclature, and paid a tribute to the valuable work of Mr. Francis Hemming, honorary secretary of the Commission during the past twenty-two years, who on the grounds of ill-health had been compelled to offer his resignation. A colloquium had been meeting during the week previous to the Congress, for the purpose of concluding the revision of the Rules of Zoological Nomenclature. These had been discussed at every Congress since the foundation of the Commission at Monaco in 1892, and especially at Paris (1948) and Copenhagen (1953), but a definitive text had not yet emerged. Sir Gavin stressed the necessity of this text being produced as soon as possible, in order to avoid the confusion of names that would inevitably result in its absence. He continued by emphasizing the value of congresses such as this where zoologists of all branches could meet and discuss their various problems, for there was a danger that, with the increase of specialization, workers might get so far out of touch as to be unable to profit from each other's progress. He also directed attention to the platform party, which included not only the officers and members of the permanent committee but also the members of the Darwin and Wallace families and the heads of the institutions having special associations with the lives of Charles Darwin and Alfred Russel Wallace.

Later in the morning the meeting became public and Sir Julian Huxley gave an inaugural lecture entitled "The Emergence of Darwinism". He first dealt with the development of evolutionary biology during 1858–72, when it was in full flower, until the 1890's, when William Bateson began a reaction which lasted nearly twenty years. This was succeeded by the present phase of Neo-Darwinism in which the basic concept of natural selection is related to the facts of modern genetics, ecology and palæontology. He then developed his theory that man is the chief agent for the future of evolution on this planet, and by building on the foundations of Darwinism we could use the evolutionary concept in considering the history and future development of our species. A science of human possibilities was considered necessary to help in guiding the long course of psycho-social evolution that lay ahead.

The sectional meetings started that afternoon and continued until July 23. The programmes were arranged in twelve sections: general zoology; evolution, taxonomy and genetics; marine zoology; invertebrate zoology; vertebrate zoology; comparative physiology; embryology; parasitology; cytology; ecology; animal behaviour; and zoological nomenclature.

An unprecedented number of papers had been presented for communication and many could only be 'read in title', but all those submitted by members of the Congress will be printed in the *Proceedings*. It is invidious to select any particular communication among the hundreds presented, but an exception must be made of a series of papers dealing with *Neopilina galatheae* and the Monoplacophora, comprising an account of the comparative anatomy of this very primitive mollusc by H. Lemche and K. G. Wingstrand, and molluscan phylogeny and prostomal inter-relationships in the light of *Neopilina*, both by H. Lemche.

The programmes ranged over a very wide field: the communication of zoology; the conservation of Nature; the teaching of zoology; the ancestry of man; the physiological basis of sense perception; neurosecretion; hormones; new approaches in cytology; primate behaviour; flight and migration in birds and insects; ecology and behaviour; to mention only a few of the topics discussed.

The meetings were held in the lecture rooms of the Imperial College of Science and Technology and the Memorial Hall of the Royal Geographical Society. The Reception Room and adjoining rooms in the Students' Union provided an extraordinary and valuable range of services.

The main social functions included receptions at the British Museum (Natural History); the Senate House, University of London; and the Zoological Society of London, in its gardens in Regent's Park; also a private reception by the Shell Petroleum

Company. On Sunday there was an orchestral concert in the Royal Albert Hall in which all the items were associated with animals, and the composer of the overture "The Wasps"—Vaughan Williams—happens to be the grand-nephew of both Charles Darwin and his wife. There were also excursions to Down House, Juniper Hall and Whipsnade Park, in addition to long tours after the Congress.

The final plenary session began with two papers, the first by E. N. Pavlovsky on "Some Modes of Evolution of Infections and Parasitic Diseases", with special reference to work in the U.S.S.R.; the second by J. Millot and J. Anthony, "Resultats actuels de l'étude du Coelacanthe *Latimeria chalumnae* Smith, dernier des Crossoptérygiens", comprising the first detailed account of the anatomy of this interesting archaic fish.

Sir Gavin de Beer then presented the recommendations of the Colloquium on Zoological Nomenclature and mentioned that, under present conditions, it is no longer possible to carry on the work of the Nomenclature Commission on an honorary basis. The International Trust for Zoological Nomenclature, now under the chairmanship of Lord Hurcomb, will have a paid secretary, Mr. R. V. Melville, with a secretarial staff, to undertake the heavy work involved in correspondence and publications. It is hoped that the revised rules of Zoological Nomenclature will be issued within six months.

Sir Gavin also submitted a resolution by Section I "That this widely representative meeting of zoologists from many nations participating in the Fifteenth International Congress of Zoology wishes to place on record in Plenary Session the great urgency of safeguarding the fauna and flora of the Galapagos Islands and welcomes the project, initiated by the International Union for the Conservation of Nature, for establishing on the Islands an International Biological Station for research and for assisting the Authorities of Ecuador in the task of conservation, and trusts that every support will be given by all concerned to the early and successful realization of this vital project".

The resolutions were passed with acclamation and it was then announced that the next Congress would be held in the United States during 1963. Various changes in the Permanent Committee were announced: Prof. J. G. Baer (Neuchâtel) was elected president in succession to M. Caullery (deceased); P. Pierre-Grassé (Paris), secretary-general in succession to L. Fage (resigned); C. F. A. Pantin (Cambridge) and B. Rensch (Münster), in succession to E. Hindle and A. Kühn (resigned); and representatives of four new countries were added, P. Sawaya (Brazil), M. B. Lal (India), T. Jaczewsky (Poland) and J. Uchida (Japan). The new Committee also includes V. d'Ancona (Padua), H. Boschma (Leyden), S. Horstadius (Upsala), A. R. Jorge (Lisbon), E. N. Pavlovsky (Moscow), G. G. Simpson (New York), R. Spärck (Copenhagen), V. van Straelen (Brussels) and E. Witschi (Iowa City), who continue to represent their respective countries.

With the words "Little bear now makes way for big bear", Sir Gavin de Beer introduced the new president of the Permanent Committee, the towering Prof. J. G. Baer, of Neuchâtel, who then addressed the meeting, thus concluding a very successful zoological congress.

EDWARD HINDLE

THE NATIONAL VEGETABLE RESEARCH STATION

MEMBERS' DAY

THE founders' meeting of the National Vegetable Research Station Association took place at the Station at Wellesbourne on June 12. The Association, membership of which is open to anyone interested, aims to foster closer contacts between the research staff of the Station and all concerned with the various aspects of vegetable production in Great Britain. Members elected officers to manage the Association's affairs, and after the meeting the party made a tour of the Station, and members of the staff spoke about their work and demonstrated aspects of it in the field.

The Plant Breeding Section showed first-generation breeding material of spring cabbage obtained under a project to develop a dual-purpose variety, able to be used either for greens or as hearted cabbage. Also on view were the winter-hardy survivors of a number of lines of peas derived from crosses of the hardy maple type with some of the non-hardy commercial varieties. This work was being undertaken in an attempt to develop autumn-sown wrinkled varieties to extend the canning and quick-freezing season. Brief descriptions were given of work on the breeding of non-bolting bunching beet and disease-resistant lettuce, on the production of hybrid onions, and on the inbreeding of brussels sprouts.

The parts of the Pathology Section's work which were demonstrated were those dealing with parsnip canker, tomato stem rot (*Didymella*) and the *Ascochyta* diseases in peas. The natural resistance of parsnip varieties to canker was being tested; existing commercial varieties showed little or no resistance, but some new selections were promising. Members saw plots of outdoor tomatoes being prepared for fungicide tests on *Didymella*, following previous work showing that captan and maneb would greatly reduce the severity of attack. Other diseases being studied included big vein and botrytis diseases of lettuce, clubroot of crucifers, silvering of red beet and mint rust.

The Chemistry Section concentrated on aspects of its field work and several long-term experiments on the mineral composition of soil and plant, soil structure, and plant growth were shown. One of these experiments had made it clear that for crops like brassicas with a high nitrogen requirement, inorganic nitrogen was better than organic, and that no practical advantage was to be gained from splitting dressings of inorganic nitrogen. A nitrogen–phosphorus–potassium factorial experiment, now in its fifth year, showed that large differences in the responses of various crops to levels of phosphorus and

potassium could occur; thus potatoes and red beet were showing severe symptoms of potash deficiency on those plots which had had none since the experiment began, while cabbage and carrots had not yet shown any such effects. The laboratory work of this section was concerned with the biochemistry of germination and early growth and with the effect of growth-controlling substances on chemical systems.

The calculation of potential evapo-transpiration of a growing crop from meteorological data had been made possible by the work of Penman and others. The Irrigation Section was developing a practical alternative to these calculations for the commercial grower, and showed a gauge which simulated the water-balance of a plant–soil system and allowed the water deficit at any time to be read off directly. The gauge had been found to give better results than other methods currently available to growers. The section also showed experiments designed to detect the existence or otherwise of moisture-sensitive periods in vegetable crops. Such periods had been found to exist in turnips and peas, and knowledge of them was crucial to good irrigation practice.

The Weeds Section was making ecological studies on the weed seed populations in the plots of the long-term manurial and cultivation experiments, and was also studying the dormancy of weed seeds. The successful use of dinoseb (amine) as a residual pre-emergence herbicide for French and runner beans was demonstrated in the field, also a similar use for simazin on sweet corn.

Various aspects of their work on onions were shown by members of the Physiology Section. These included a trial of varieties for their suitability as pickling onions, and experiments on storage-temperate effects with onion varieties used for the production of sets. Fundamental work being done on competition between crop and weed was mentioned, and members saw a field experiment on one of the practical aspects of this work, namely, the timing of early weeding in row crops. Important depressions in final yield in onions had been shown to result from relatively small delays in the first weeding date.

The Entomology Section presented results from studies on carrot fly and cabbage root fly. Existing methods for controlling carrot fly by seed-dressing followed by top sprays were expensive and sometimes gave but partial control of the pest; new methods using the incorporation of insecticides in the soil were being developed, and low rates of aldrin and dieldrin were found to give complete control of both generations for at least two years. Extensive testing had been done on the effect of soil insecticides on the flavour of carrots and had shown that dieldrin in particular produced little or no detectable changes in flavour. Assays of insecticide residues in the field had been started recently, using *Drosophila*; it had been found that from one application of aldrin at 2 lb. per acre four years previously an appreciable quantity still remained in the soil.

Satisfactory methods for the control of cabbage root fly by insecticides were now known, and attention was being concentrated on the ecology of the pest and the predators of its egg and larval stages. This was begun after it had been found that broadcast application of soil insecticides could lead to increased attack by cabbage root fly larvæ. Recent studies showed that some thirty species of insect were predators of the root fly in its early stages and that they could eat 95 per cent of the eggs laid in a season; it was these predators that were being reduced by the broadcast application of insecticides, and the situation illustrated one of the possible dangers in the indiscriminate use of insecticides in the field. Mention was also made of work on lettuce root aphid and on the control of pea moth.

The Statistics Section was concerned with all the mathematical and statistical problems arising in the work of other sections. In particular, results were being accumulated and methods developed for the analysis of plant growth data, with the object of providing more detailed interpretation of long-term field experiments.

J. A. Nelder

THE MECHANICAL ENGINEERING RESEARCH LABORATORY

More than 1,700 visitors from industry, universities, technical colleges and other research organizations attended open days at the Mechanical Engineering Research Laboratory on June 4 and 5. All the work at East Kilbride and Thorntonhall was on show and two new laboratory buildings, completed in 1957, were open for inspection for the first time.

The Metrology Building includes a wing, with a floor area of about 6,000 sq. ft., controlled in temperature to within $\pm 0{\cdot}1°$ of the standard temperature of 20° C. This strict temperature control enables full advantage to be taken of the accuracy of the wide range of precision instruments available for checking the dimensional accuracy of engineering components. The metrology section provides a service to other parts of the Laboratory and to industrial firms ranging from the measurement of surface finish to the certification of the accuracy of large gear-hobbing machines. For the latter work, equipment has been developed for the autographic recording of errors in alignment between the hob-saddle motion and work-table axis of hobbing machines; errors in alignment of 0·0001 in. over a machine traverse of 5 ft. can be recorded. The Mechanisms, Engineering Metrology and Noise Control Division is also developing automatic machines for precision measurement. A prototype measuring bench has been designed for recording errors in precision lead screws: a moiré fringe technique is used and pitch errors are recorded to an accuracy of 0·0001 in. The Metrology Building also houses an anechoic chamber in which the noise-generating properties of complete machines and their component mechanisms can be measured. Preliminary tests on commercial bearings and precision bearings of the same nominal size have shown that the former were noisier, that speed was an important factor and that the radial and axial loads had no significant effect on the noise generated.

The new Heat Building is provided with large quantities of electricity, high- and low-pressure steam, and cooling water for heat-transfer research on a substantial scale. One of the aims of the Heat Division is to provide more accurate basic design data for conventional and novel types of heat exchanger and to analyse the performance of industrial heat-exchange equipment. An experimental rig for measuring heat transfer to regenerator matrices has been used to determine the heat-transfer coefficient for the flow of air through a matrix of randomly packed steel balls. The temperature of the inlet air is varied sinusoidally so that the results are in a convenient form for mathematical analysis.

The Heat Division is also concerned with the preparation of consistent tables of the thermodynamic and transport properties of technically important fluids over wide ranges of temperature and pressure. A DEUCE computer has recently been installed, and is being used principally for this work. A start is being made with argon and carbon dioxide, and it is intended to re-calculate the steam tables and extend their range. Most of these tables will be based on existing data, but some experimental determinations of transport properties are being made. An oscillating disk method is being used to measure the viscosity of gases at moderate temperatures, at pressures up to 100 atmospheres.

The Materials Division is concerned principally with fatigue and creep of metals. It seeks, on one hand, to find out more about the stresses to which components will be subjected in service, and, on the other, to obtain a better understanding of how the material will behave under those stresses. An attempt is being made to explain the mechanism of fatigue damage and failure in terms of dislocation theory. Study of the hardening and embrittlement of mild steel caused by low-stress fatigue loading has shown that, in tensile tests subsequent to cyclic stressing, slip was confined to a few planes which had hardened during the cyclic stressing. This is difficult to account for on a random-network dislocation theory, but can readily be explained if the nature of the preparatory slip is an essential feature of the production of dislocation sources.

Measurements of the propagation of fatigue cracks in thin sheets of various metals have shown that, in the early stages, the rate of growth of a crack is proportional to the current length of crack; at very low stresses, however, non-propagating cracks may form. For fatigue tests on large components, such as railway axles, a novel electronic technique has been evolved which enables rotating–bending tests to be simulated without any rotating parts.

The Materials Division's work on creep is concerned with the behaviour of typical engineering materials under complex-stress systems. For constant loading, the relation between creep-rate, stress and time has been established for a range of metallic alloys at various working temperatures. A generalized version of this relation has now been derived for general-loading complex-stress systems, that is, those in which the stresses are varied during the course of a test. Results of these tests have been compared with various mechanical theories of creep; none of them gave predictions agreeing with the experimental data, although the age-hardening and strain-hardening theories gave upper and lower bounds, respectively. For the special case of relaxation (where the total strain remains constant) a reasonably close prediction of the complex-stress relaxation/time curves was given by the age-hardening theory for an aluminium alloy at 200° C. and a magnesium alloy at 50° C.

The Fluids Division is concerned with basic and applied research on mechanical engineering flow problems, particularly those occurring in water-turbines and pumps, valves, fans and compressors, and oil-pressure mechanisms. Flow measurement is essential in all hydraulic work, and improved techniques have been developed for measuring large rates of flow of liquids in pipes. Electronic equipment has been developed to record the rotational velocity of up to twenty-one propeller current-meters automatically. Advantages over conventional chart recording are convenience and the immediate indication of the number of revolutions in a pre-determined time. A new integration technique has been devised for calculating total flow from point velocity readings (derived from current meters or pitot tubes) in a circular pipe; the mean velocity can be determined with at least as great an accuracy from fewer point readings than equivalent methods. Its use will save time and expense, particularly in field trials. In the salt-velocity method the mean velocity is measured by suddenly injecting into the pipeline a quantity of salt solution of higher electrical conductivity than that of the water. Its passage between two downstream positions, a known distance apart, is timed. Here again electronic techniques have been used to increase the sensitivity of the method and also to provide a direct indication of the time interval. Four flow measurement techniques, the current-meter, pitot-tube, salt-velocity and salt-dilution methods, have been tried out simultaneously in a 40-in. diameter pipeline of a Scottish hydro-electric station at flow rates up to 70 cubic feet per second. Results from all methods agreed within $\pm$ 2 per cent of the current-meter values, which were taken as the reference.

Research on hydraulic transmissions is also the concern of the Fluids Division. There is a growing realization in industry that the steplessly variable hydrostatic transmission provides the ideal link between an internal combustion engine and the work it has to do. A 15-h.p. pump-motor has been built with the usual reciprocating pistons replaced by reciprocating balls, resulting in an appreciable reduction in cost. It has an overall efficiency of about 80 per cent for speeds between 1,000 and 3,000 r.p.m. A 40-h.p. axial-type pump-motor has been designed, and fitted with instruments to provide basic design information on piston slipper-pads and port-plates.

The Lubrication and Wear Division undertakes experimental and theoretical investigations of the factors affecting the design and operation of all types of bearings. Gas-lubricated bearings have advantages over conventional oil-lubricated bearings for special applications. Investigations of self-acting air-bearings, where the load-carrying film is generated by hydrodynamic action, have shown that with a conventional clearance of 0·001 in., a 1-in. diameter bearing can carry a load of 1 lb. per sq. in. of bearing area for each 1,000 r.p.m. Such bearings have run successfully at speeds up to 100,000 r.p.m.

A clear understanding of the processes of lubrication and wear is essential if machines are to last long enough to give an adequate return for their cost. New methods of reducing wear often depend on a better understanding of the various factors which cause it. Much attention is therefore given to

fundamental studies of physical changes in the structure of surfaces when they are deformed by abrasion or other processes.

The manufacture of almost all metal articles involves plastic deformation of the metal. The Plasticity Division's work is directed towards providing a better understanding of the mechanism of plastic deformation so that economies in plant design and more efficient operation may be achieved. When α-uranium is irradiated with neutrons a greatly accelerated creep takes place, even under small loads. The mathematical theory of plasticity has been applied to explain, in detail, the mechanism of this phenomenon in a uranium aggregate, starting from the known crystallographic properties of a single crystal of uranium.

In many metal-working processes the deformation takes place in the presence of hydrostatic pressure which may be considerably greater than the yield stress of the metal. Equipment has been developed for carrying out simple mechanical tests under pressure up to 100 tons per square inch. Tensile tests on various materials under a range of hydrostatic pressures have shown that there is, generally, a marked increase in their ductility as the pressure is increased. With copper, aluminium and cast-iron the increase in ductility is gradual, with zinc and 'Mazak' (a zinc-base alloy) there is an abrupt change from brittle to ductile behaviour for a small change of pressure. The possibility of extruding brittle materials by carrying out the process under high pressure is being examined. R. J. F. Franklin

ACCURATE MEASUREMENT OF THE VISCOSITY OF LIQUIDS

A SYMPOSIUM on the "Accurate Measurement of the Viscosity of Liquids", arranged jointly by the Institute of Petroleum and the British Society of Rheology, was held on June 6 at the Institute of Petroleum, 61 New Cavendish St., London, W.1. It was under the chairmanship of Mr. W. Pohl (chairman of the Lubrication Committee, Institute of Petroleum) and Prof. E. G. Richardson (University of Durham, president of the British Society of Rheology).

The revised standard methods (British Standard 188 : 57 and Institute of Petroleum, 71 : 58) for measuring the viscosity of liquids in c.g.s. units, which incorporate the experience and the results of co-operative experimental work obtained in Britain and other countries during the post-war years, describe a 'step-up' procedure for the calibration of glass capillary-type viscometers, using master viscometers and freshly distilled water at 20·00° C. with an agreed viscosity of 1·002 centipoises (1·0038 centistokes). Dr. R. Roscoe (University of Durham) pointed out in a paper on the determination of viscosity by the oscillating vessel method that further research on accurate absolute methods of viscosity measurement of liquids as standards is desirable, because of the difficulty in the capillary tube method of the elimination of the end correction. The slight inconsistencies in the careful measurements of J. F. Swindells, J. R. Coe and T. B. Godfrey, who found the viscosity of water at 20·00° C. to be 1·0019 ± 0·0003 cP., arise from small differences in the ends of paired tubes. The oscillating vessel method, advocated by Prof. Andrade and A. Chiong, may prove to be better for accurate viscosity measurements. Dr. Roscoe described a series of precise measurements with water, using oscillating vessels, both spherical and cylindrical, supported by a graduated capillary tube so that the water acted as its own thermometer. In this preliminary work a value obtained for the coefficient of viscosity for water at 20° C. was 1·002 5 ± 0·000 5, but an analysis of the sources of error in the results suggests that with fairly simple improvements in technique, for example, using cylindrical vessels and measuring angular velocity rather than amplitude of oscillation, the accuracy of the method, of the order one part in 10,000, could be substantially greater than that obtained in capillary tube measurements.

The measurement of viscosity by means of a vibrating system using an electronic counting technique was described by Mr. M. T. Browne (Imperial College and Queen Elizabeth College, London), who gave the method of calculating viscosity values for water from the logarithmic decrement, the electronic apparatus counting the number of cycles of vibration occurring while the amplitude decreases from one value to half this value.

For oils of higher viscosity the liquid is located on a plane end of the rod. The apparatus is particularly adapted to measure small changes of viscosity.

In a paper on the precise measurement of kinematic viscosity in the petroleum industry, K. A. Lammiman and P. P. Morris (Esso Research Ltd.) described standard instruments and modern equipment involving electronic timing devices, precisely controlled thermostat baths for a temperature-range from − 100° to 200° C. and above, and the technique used for the scrupulous cleaning of instruments by pressure jets of solvents. The authors described methods of measuring viscosity when only small amounts were available; these required the use of the standard miniature British Standard viscometers, torque viscometers such as the plate-cone type, vibrating systems and a comparative method of the rate of descent of an index of oil (0·05 ml.) in an inclined capillary.

Methods of examining opaque oils and fuel oils and their heat pretreatment were also described, as well as semi-automatic methods using viscometers fitted with platinum probes at the fiduciary markings.

During the past two decades industry has become 'shear' conscious mainly in connexion with the requirements of the Armed Services and the automotive industry. At the rates of shear occurring during flow in standard viscometers, the viscosity does not show variations, but at high rates of shear the coefficient of viscosity is no longer a constant. Dr. R. Schnurmann (Esso Research Ltd.) described a jet viscometer in which frictional heating is practically eliminated when a liquid is forced slowly and in individual drops through a narrow streamlined constriction.

By varying the pressure difference across the aperture or the temperature the rate of shear can be altered over a wide range. The kinetic energy correction can be determined experimentally and is smaller by a factor of 2 than for long capillary viscometers, which usually have a length to diameter ratio of 100.

The viscosity of any liquid containing asymmetric molecules can be made to show a temporary viscosity-fall during flow because of molecular orientation in the flow stream. Castor oil, for example, appears to have a constant viscosity coefficient for rates of shear up to 5,000 sec.$^{-1}$ yet at a rate of shear of 250,000 sec.$^{-1}$ its viscosity is reduced by about 25 per cent. The apparent viscosity over a wide range of rate of shear has a falling characteristic with a point of inflexion, the curve bending upward when an appreciable proportion of the pressure-volume energy is converted into kinetic energy and when turbulent flow takes place. The viscosity of a liquid containing large asymmetric molecules, as in an oil thickened with polymer, which has suffered a permanent viscosity loss through severe shearing, is more sensitive to temperature change than that of the liquid at low rates of shear. On the other hand, when a liquid suffers a temporary viscosity reduction its viscosity–temperature coefficient is smaller while a shearing stress is being applied than when the stress has been removed.

The complexity of the flow behaviour of solutions of some polystyrenes at high dilution was emphasized by Dr. P. P. Rutherford (University College of North Staffordshire), who showed that with a capillary-type viscometer anomalous $\eta sp/c$ and ln $\eta r/c$ values were obtained at the highest dilutions. Upswings in the graphs were observed when these values were plotted against the concentration over the range 0·2–0·4 gm. of polystyrene (mol. weight less than 40,000). The concentration at which these upswings occurred depends on the intrinsic viscosity or molecular weight, the temperature and the kind of solvent used. The flow times for the dilute solutions left in contact with powdered glass for several months were found to be almost unaltered, indicating that adsorption effects on the viscometer walls are negligible. Before an explanation of the anomalies is offered further work is necessary not only on viscosity measurements of fractionated polystyrenes of low molecular weight but also by the measurement of light scattering, density and other properties in the low concentration range.

At the first World Petroleum Congress held at the Imperial College of Science and Technology, 1933, the opinion was expressed by Dr. Guy Barr of the National Physical Laboratory that the international standardization of viscosities should be made with viscometers of known characteristics, as these are much less likely to change than standard viscosity oils. This view is at present maintained by both the British Standards and Institute of Petroleum viscosity committees, and in a short report by Mr. W. O. Jennings (National Physical Laboratory) and Dr. E. W. J. Mardles (chairman of the Institute of Petroleum Viscosity Panel) it was shown by results obtained at the National Physical Laboratory that the average change in the constant of four master viscometers over the period 1953–58 was no greater than + 0·01 per cent.

Information from observation books at the National Physical Laboratory indicated the satisfactory working of the standard methods. The report using these results gives the method of establishing a series of reference viscometers on the basis of the agreed viscosity value of water. The accuracy of the method was assessed by cross checking with other laboratories.

The meeting discussed the various factors by which high precision is attainable and in particular the difficulty of using the quadratic equation, $\nu = Ct - B/t$ where ν is kinematic viscosity, C the viscometer constant, t time of flow and B the coefficient of the kinetic energy of efflux, B being known to be variable. The standard methods indicate ways and means of avoiding the use of B or obtaining a working value for it by calculation.

The experimental determination of term B can conveniently be made, as shown in the report, by first obtaining the value for C, using a flow time not less than 1,200 sec.; then, with a flow time of about, but not less than, 200 sec., evaluating B from the equation $B = Ct^2 - \nu t$, where t is the short flow time and C the constant already obtained.

L. A. Steiner (Viscosity Panel, Institute of Petroleum) described a series of experiments showing the variation of the coefficient B under different conditions of experiment. Using sets of viscometers of the same design but with one variant, namely the capillary diameter, the true constants could be ascertained by a graphical method. It was shown that the variation in the coefficient B could be explained partly by end effects, the shapes of the entry and exit ends of the capillary affecting the results; part of the efflux energy is recovered during the filling of the bulb.

The meeting included the exhibition of some new viscometers and equipment, and was concluded by a visit to the viscometry, chronometry and thermometry sections of the National Physical Laboratory on June 7.

E. W. J. MARDLES

THE BRITISH GELATINE AND GLUE RESEARCH ASSOCIATION

THE fifteenth meeting of the Research Panel of the Association was held on June 12, with Dr. G. R. Tristram (University of St. Andrews) in the chair. The meeting was well attended and was followed by demonstrations and discussions in the Association's Laboratories at 2*a* Dalmeny Avenue, London, N.7.

The meeting commenced with a review by Prof. A. Neuberger (St. Mary's Hospital Medical School, London), with the title "General Aspects of the Metabolism of Collagen". Prof. Neuberger outlined the development of the use of radioactive amino-acids in studies of the laying down and turnover of collagen, and the part which the soluble collagens play in this. He also described work showing the inability of an animal to make use of free hydroxyproline (and hydroxylysine) in collagen synthesis, the hydroxyproline being formed at some stage by the hydroxylation of bound proline.

Drs. N. M. Green and D. A. Lowther (St. Mary's Hospital Medical School) gave a paper "Biosynthesis of Collagen", describing their recent researches. In these they have made use of tissue slices obtained from the connective tissue tumour formed when carrageenin is injected under the skin of a guinea pig. Two problems were studied: the first, the conversion of proline into collagen-bound hydroxyproline, and secondly, the precursor relationships

between the soluble collagens together with the search for other collagen-like precursors in the cells.

The microtomed tissue slices were incubated in a Krebs medium, which included radioactive proline, for 4 hr. at 37° C. under oxygen. After washing, they were ground and the soluble collagens extracted. The results showed that, in all the purified collagen fractions, the radioactivity of the hydroxyproline was comparable with that of proline, showing that it was derived from the radioactive proline in the medium. In addition, the collagen soluble in neutral salt showed a very much more rapid incorporation of radioactivity than acid-soluble collagen, which in turn showed greater activity than the insoluble collagen. The addition of free hydroxyproline to a culture did not lead to a reduction in the ratio of radioactive hydroxyproline to radioactive proline, while the addition of radioactive hydroxyproline to a medium free of radioactive proline showed no significant incorporation into the collagen. Changes in ratio of specific activities for collagen, hydroxyproline and proline with incubation time, in the presence of radioactive proline, suggest that hydroxylation occurs before incorporation into the protein. Further experiments, in which subcellular fractions were isolated from the tissues, showed that collagens soluble in neutral salt are present in certain fractions. It was suggested that there is a continuous series of collagens of decreasing solubility, of which neutral salt-soluble and acid-soluble collagens are two arbitrary fractions.

A lively discussion followed the paper, and a vote of thanks was proposed by Mr. S. Henson (William Oldroyd and Sons, Ltd.) and seconded by Dr. J. E. Eastoe (Royal College of Surgeons).

A number of analytical techniques were included in the demonstrations at the laboratory. In each instance, part or the whole of the determination was carried through for each group of visitors. Mr. A. A. Leach described his modified Neuman and Logan technique for hydroxyproline determination. Mr. W. G. Cobbett and Dr. A. W. Kenchington demonstrated tyrosine estimation by ultra-violet absorption and by a modified colorimetric method. Dr. G. Stainsby showed how the biuret method could be applied to estimating gelatine concentrations, and Mr. J. T. Taylor carried out the Kodak test for the setting time of a gelatine solution. Mr. A. M. Kragh showed the powerful action of gelatine and glue as flocculation and filtration aids, when used in the correct conditions.

Much interest was aroused by the demonstration by Dr. A. Courts of the properties of a form of soluble collagen which can be isolated from collagenous tissues after they have received pretreatments of the type used in gelatine manufacture (for example, a cold alkaline soak). Substantial percentages of the collagen could be solubilized in this way using 0·1 *M* citric acid as solvent. The solution was very viscous but, on warming to 43° C., a rapid conversion to gelatine occurred, and the viscosity fell more than 40-fold to a normal value for gelatine. It was possible to precipitate the soluble collagen as fibre by the same procedures as applied to acid-soluble collagens from native tissues. It appears clear that bonds formed when the collagen became insoluble have been broken, enabling the original structural units to be dissolved.

Also on show were equipment for fractionation (W. B. Langston), small-scale gelatine extraction (F. W. Wainewright and A. P. Williams), and the use of *XE* 97 resin for the separation of gelatine components by the method of G. E. Russell (Ilford, Ltd.) (A. A. Leach).

A. G. Ward

NUMERICAL WEATHER FORECASTING

THE methods of numerical prediction by electronic computer of the atmospheric pressure field now being investigated are based on finite difference approximations to the differential coefficients in the equations of motion. It is required to forecast the variation with time of the height h of an isobaric surface, and the differential coefficients of this quantity occur in the equations.

Starting with a set of values of h at the grid points of a map, the finite-difference approximations can be computed from more than one set of combinations of the values. The effects of using different combinations have been examined in the numerical forecasting research unit of the Meteorological Office, and the results are published in a recent paper entitled "Experiments in Numerical Integration", by E. Knighting, D. E. Jones and Mavis K. Hinds (*Quart. J. Roy. Meteor. Soc.*, **84**, 91; 1958).

The quantities which have to be computed are the Laplacian $\frac{\partial^2 h}{\partial x^2} + \frac{\partial^2 h}{\partial y^2}$ and a Jacobian $J(h,\zeta)$, where ζ is the vertical component of the vorticity, which in turn is expressed as a function of the Laplacian.

The grid points are arranged in square sets. One basic set of grid points is that of the eight points at the centre, corners and mid-points of the sides of a square. These are numbered 0 at the centre, 1, 2, 3, 4 at the mid-points of the sides—with the easternmost point of this set 1, northern 2 and so on counter-clockwise—and 5, 6, 7, 8 at the corners—with the north-east point 5 and the north-west point 6 and so on as before. Then one finite-difference approximation to the Laplacian is:

$$(h_1 + h_2 + h_3 + h_4 - 4h_0)/a^2$$

where h_i is the value of h at point i and $2a$ is the length of a side of the square. Another approximation is:

$$(h_5 + h_6 + h_7 + h_8 - 4h_0)/2a^2$$

Similar, more elaborate combinations apply to the Jacobian.

The authors describe the results of using these different combinations on actual meteorological situations, one of which is the great north-westerly gale of January 31, 1953, which led to the North Sea floods of the following night. Considerable differences are found to occur between the maps of the predicted pressure distributions according to the particular combinations employed. These differences occur even in the centre of the large area dealt with, though that

is the part in which, because of its distance from the edges with their specified boundary conditions, errors are usually smallest. The difference between two combinations was about 40 per cent of the actual change in two cases and 10 per cent in a third.

These are serious differences, and the authors point out that on some occasions the choice of a geometrical method of making the finite difference approximations has a decisive effect on the forecast. The differences are believed to be associated mainly with the Jacobian, and the authors consider the remedy will have to be sought by using more complicated finite-difference approximations for the derivatives. This would, of course, mean greater complexity and time in the computation.

RIBONUCLEIC ACIDS IN LIVER CYTOPLASM

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STUDIES in this laboratory on cytoplasmic ribonucleic acid, as influenced by induction of liver tumours[1] or by a change in hormonal status[2–4], have emphasized the need for closer study of the ribonucleic acid in the microsomal and supernatant fractions obtained from normal liver. Microsomal ribonucleic acid and supernatant-fraction ribonucleic acid may differ in function[4,5]; they undergo different changes after adrenalectomy[2–4], and differ in the time of maximum labelling after injection[4] of orotic acid-6-^{14}C [4]. Labelling data[4] were compatible with, but did not prove, the postulate[7,8] that microsomal ribonucleic acid is derived from ribonucleic acid in the supernatant fraction. Supernatant-fraction ribonucleic acid might be derived from acid-soluble nucleotides rather than from nuclear ribonucleic acid[9,10], but no evidence to support this possible relationship emerged from a comparison of the labelling of acid-soluble uridine nucleotides with that of cytoplasmic ribonucleic acid, after injection of labelled orotic acid[6].

The study of precursor-product relationships *in vivo* is hampered by the apparent heterogeneity of the ribonucleic acid in microsomal[11–14] and supernatant[4,8,11,12] fractions. Published procedures[12–18] were not ideal for the purpose of partitioning the ribonucleic acid among several sub-fractions. This purpose has now been achieved by fractionating tissue proteins (ribonucleoproteins ?) under mild conditions as described below, with tissue samples isolated at different times after injection of orotic acid-6-^{14}C; the time course of ribonucleic acid labelling served as a guide in choosing conditions for separation.

Tissue fractions. Liver homogenates, prepared with 0·25 *M* sucrose from fasted rats given labelled orotic acid, were freed from nuclei and mitochondria, and centrifuged for 90 min. at 14,500 *g* to give microsomal and supernatant fractions[3,4]. (The 'ultracentrifugal pellet' which can be obtained by re-centrifugation at a higher *g* value, and which would be included in the 'microsomal' fraction in some laboratories[5,13], resembles our 'ultracentrifugal supernatant' fraction rather than our microsomal fraction in its time course of labelling[4,8] and in its changes after adrenalectomy[2–4] or in liver tumours[1].) The fractions were frozen and stored at − 30°; with microsomal fractions the freezing facilitated the subsequent extraction of ribonucleoprotein.

Analytical methods. Solid samples were counted at infinite thickness, and analysed for ribonucleic acid as previously[3,4]. Almost all the original ribonucleic acid was recovered in the sub-fractions[13,17]. For the subsequent isolation of ribonucleic acid mononucleotides, digestion was performed with 1·5 *N* potassium hydroxide for 42 hr. at 37°, to ensure complete conversion of the ribonucleic acid to mononucleotides[19,20]. The digest was treated with perchloric acid (to 3 per cent) to remove protein, neutralized with potassium hydroxide, centrifuged to remove perchlorate, and applied to a 'Dowex 1' (formate) column. Gradient elution chromatography was carried out with formic acid[21] to give individual nucleotides, with no attempt[20] to separate 2′- and 3′-isomers. The extinction readings (260 mμ) were assumed to be a valid measure of the amounts present, except for cytidylic acid which, being contaminated with protein[20], was estimated by analysis of the peak for phosphorus. A further difficulty with cytidylic acid is that some deamination, to give uridylic acid, may occur during the digestion[20,22]; however, this deamination was probably slight because of the presence of tissue protein[19]. Values are expressed relative to guanylic acid as being probably least open to errors of estimation, and are quoted as 'apparent' base composition, since there may still be undetected errors in the present methods. The radioactivity of nucleotide solutions was determined at infinite thinness, with aliquots dried on duralumin planchets.

Supernatant fraction. All fractionations were carried out at about 2°. The procedure for the supernatant fraction (Fig. 1) was based on previous experiments[4]. The ribonucleic acid precipitated by calcium ions partially redissolved on treatment with oxalate[14]. Both the residual ribonucleic acid and the re-dissolved portion which remained soluble on adding streptomycin sulphate[18] seemed, on the grounds of labelling results, to be worthy of closer examination, together with ribonucleic acid precipitated from the calcium-soluble fraction by ammonium sulphate[4] at 40 per cent of saturation. There appeared to be differences in base composition (Fig. 1), the last-named fraction being deficient in guanine; but attention is directed particularly to the differences in the time course of ribonucleic acid labelling (Fig. 2). The peak of labelling lay at about 12·5 hr. for the ammonium sulphate (40 per cent) precipitate, at about 20 hr. for the streptomycin supernatant and not earlier than 42 hr. for the residual (oxalate-insoluble) ribonucleic acid. (Note logarithmic axes.)

If the ribonucleic acid with a peak at 12·5 hr. were the precursor of that in other sub-fractions, it should have relatively high labelling up to 12·5 hr.[23]. Here it is necessary to consider the labelling not of ribonucleic acid as a whole but of the uracil moiety, since, as has now been confirmed, the labelling of

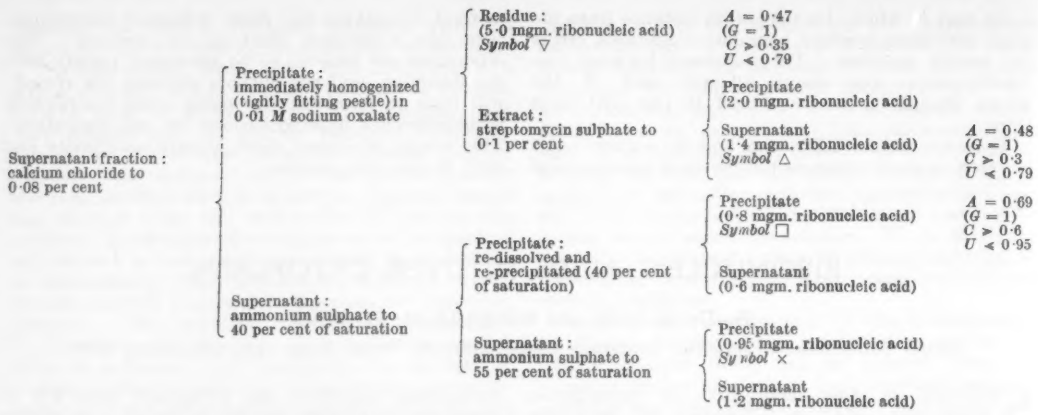

Fig. 1. Sub-fractions from supernatant fraction. In Figs. 1 and 4, the yields of ribonucleic acid refer to an amount of liver corresponding to 100 gm. body weight; the symbols are those used in Figs. 2–6, and *A*, *G*, *C* and *U* denote adenylic, guanylic, cytidylic and uridylic acids, respectively. The mean values for the apparent base composition (see text) are given as molar ratios

cytosine is initially low but eventually as high as that of uracil[6]. Fig. 3 shows that the ribonucleic acid uracil of this sub-fraction does rapidly attain high labelling.

Since it was conceivable that the 'rapidly labelled ribonucleic acid' comes directly from acid-soluble nucleotides, possibly uridine triphosphate or uridine diphosphate[10], these nucleotides were isolated for study[4,6,21]. There was no wide gap[6] between their peak of labelling and the peak for the 'rapidly labelled ribonucleic acid' (Fig. 3). In contrast with uridine triphosphate, the diphosphate had persistently high labelling which greatly exceeded that attained by ribonucleic acid uracil. It should be mentioned that all experiments were made with a single batch of orotic acid (prepared by Dr. V. C. E. Burnop); with a different batch (from the Radiochemical Centre, Amersham) used in another study[1], higher nucleotide and ribonucleic acid labelling has been encountered at short time intervals.

Trial of an alternative fractionation procedure—precipitation at *p*H 5 in the presence or absence of buffer—indicated that the course of labelling of the precipitated ribonucleic acid (which may play a part in amino-acid incorporation[5]) resembled that of the soluble ribonucleic acid. The procedure of Kirby[24] also failed to give sharp separation.

Microsomal fraction. Fig. 4 summarizes the procedures. Ribonucleoprotein particles (Palade particles) from microsomes would probably be essentially intact if present in the *p*H 7·4 buffer or even in the *p*H 9·0 buffer[16]. Since, however, the residue

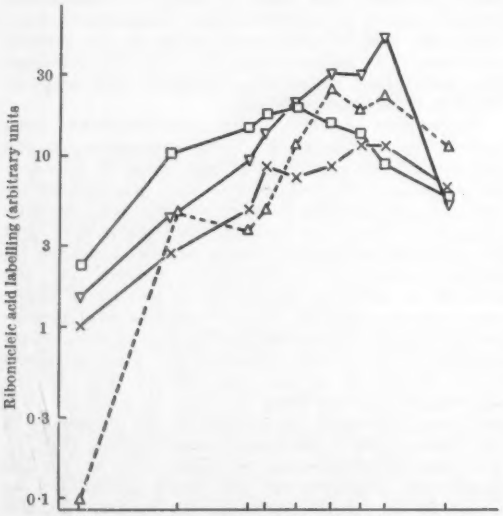

Fig. 2. Labelling of ribonucleic acid in sub-fractions from the supernatant fraction (see Fig. 1 for symbols). The axes in Figs. 2, 3, 5 and 6 are logarithmic, and the values refer to an injection of orotic acid equivalent to 1 μc./100 gm. body weight; each point represents tissue samples from at least two rats. The arbitrary units in which specific radioactivity is expressed in Figs. 2 and 5 are (counts per min.)/(per cent ribonucleic acid in sample counted), with constant sensitivity in the counting

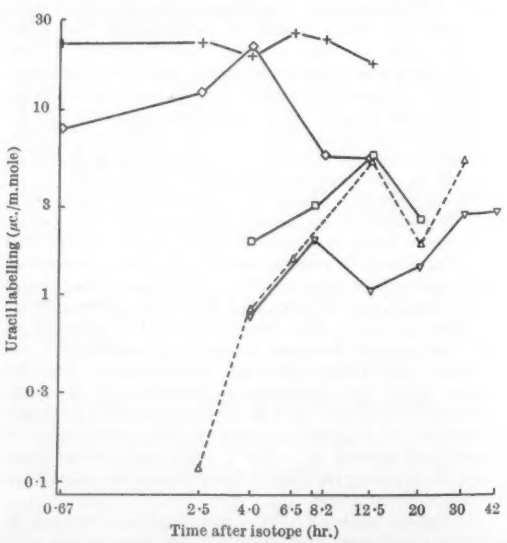

Fig. 3. Labelling of uracil in the ribonucleic acid of sub-fractions from the supernatant fraction (see Fig. 1 for symbols), and labelling of uridine diphosphate (+) and of uridine triphosphate (◇) in the acid-soluble fraction from whole liver

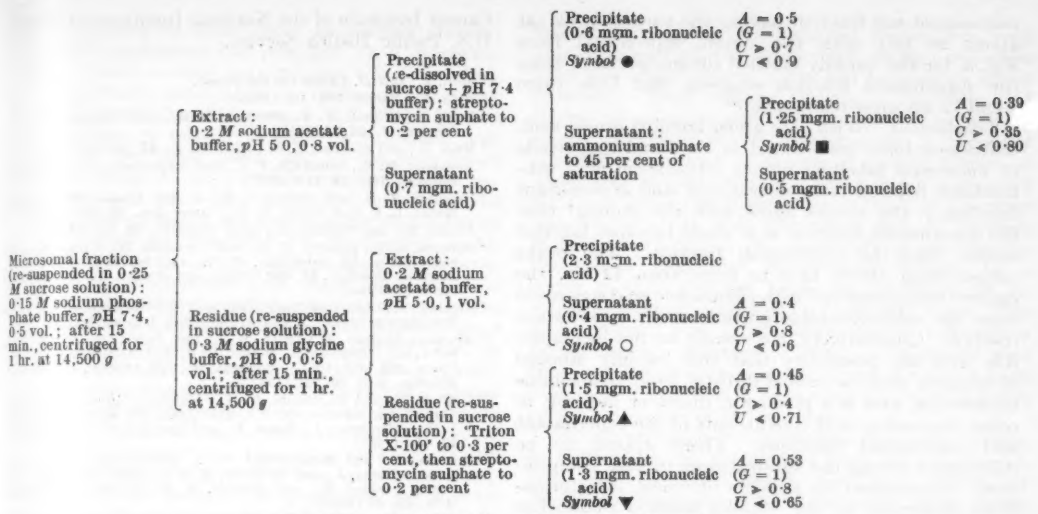

Fig. 4. Sub-fractions from microsomal fraction. See legend to Fig. 1

from the *p*H 9·0 extraction was still rich in these particles as judged by electron microscopy (kindly performed by Mr. M. S. C. Birbeck), it is conceivable that the ribonucleic acid extracted by buffer is derived not from these particles but from reticular elements[11]. The non-extracted ribonucleic acid was effectively solubilized by treatment with the non-ionic detergent 'Triton X–100'; treatment with phenol[24] was equally effective, but subsequent fractionation procedures[24] gave rather variable results.

Two fractions from the first (*p*H 7·4) extraction were given especial attention—a streptomycin precipitate, and an ammonium sulphate precipitate which had a later peak of labelling (Fig. 5). The ratio of adenine to guanine differed little among these and other sub-fractions examined, but there were apparent differences in the ratio of cytosine to uracil (Fig. 4). The *p*H 5-soluble material from the second (*p*H 9·0) extract showed labelling which was variable but notably low (Fig. 5). The residual ribonucleic acid which was solubilized by the detergent gave, with streptomycin, a precipitate which had an earlier peak of labelling than the supernatant.

Values obtained for uracil (Fig. 6) were essentially in accord with those for the labelling of ribonucleic acid as a whole. Comparison of the curve for the

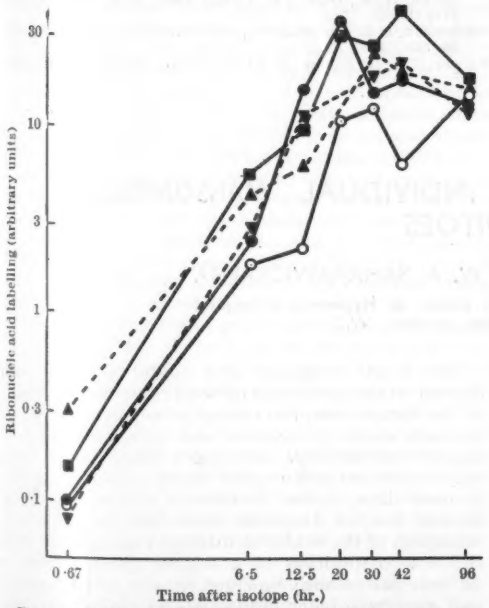

Fig. 5. Labelling of ribonucleic acid in sub-fractions from the microsomal fraction. See Fig. 4 for symbols, and legend to Fig. 2 for units

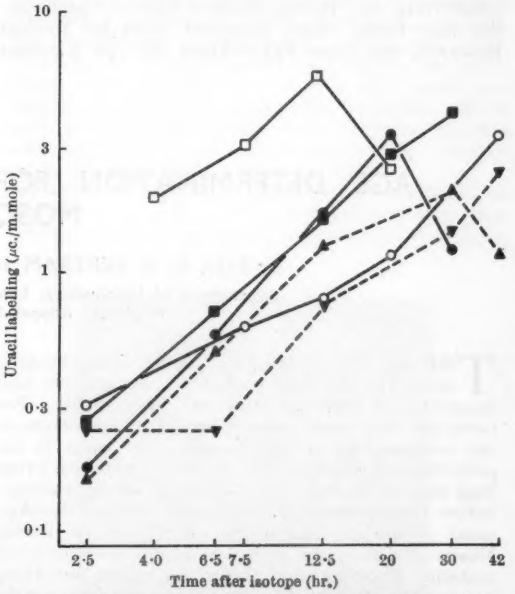

Fig. 6. Labelling of uracil in the ribonucleic acid of sub-fractions from the microsomal fraction (see Fig. 4 for symbols) and in the ribonucleic acid of the 'rapidly labelled sub-fraction' from the supernatant fraction (□; cf. Fig. 3)

microsomal sub-fraction having the earliest peak (at about 20 hr.) with the curve, reproduced from Fig. 3, for the 'rapidly labelled ribonucleic acid' from the supernatant fraction suggests that here there could be an inter-relationship[23].

Conclusions. With rats given labelled orotic acid, differences have been found in time and magnitude of maximum labelling among ribonucleic acid sub-fractions derived from microsomal and supernatant fractions; the results agree with the finding[4] that the supernatant fraction as a whole becomes labelled earlier than the microsomal fraction. The peaks ranged from about 12·5 to more than 42 hr., the earliest being observed with ribonucleic acid separated from the calcium-soluble portion of the supernatant fraction. Qualitatively, the results are not incompatible with the possibility that this 'rapidly labelled ribonucleic acid' is formed directly from acid-soluble nucleotides, and is a precursor, direct or indirect, of other ribonucleic acid constituents of the supernatant and microsomal fractions. There appear to be differences among the sub-fractions in base composition. Speculation on possible chemical transformations undergone by the 'rapidly labelled ribonucleic acid' must await further study, especially as to the homogeneity and molecular size of the various ribonucleic acid constituents. The microsomal sub-fractions warrant study with respect to amino-acid incorporation into protein, but this incorporation may well be uncorrelated with ribonucleic acid labelling[13,14].

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AGE DETERMINATION FOR INDIVIDUAL *MANSONIOIDES* MOSQUITOES

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THE age of the individual insect living entirely naturally has long challenged the interest and ingenuity of entomologists in many fields. For medically important insects, one of many factors in the epidemiology of the diseases they carry is the proportion of a population of a vector species living long enough to transmit pathogens which undergo, before transmission can take place, cyclical development within the insect for some days or weeks. Means of telling the age of mosquitoes—vectors of malaria, filariases and virus infections involving extrinsic cycles of this nature—have been sought from time to time by numerous workers, notably for anopheline carriers of malaria.

The most promising and useful methods still depend on changes in the internal reproductive organs of the female mosquito during its gonotrophic cycles. In each cycle it matures and eventually lays its eggs in the few days following a blood meal; there may be several gonotrophic cycles, each lasting two or more days, in the life-time of a mosquito. Mer[1] showed first for *Anopheles elutus* that the ampulla, a dilatation of the oviducts, increased in diameter with the first oviposition to a degree which served to differentiate recently emerged females which had not laid eggs from older individuals which had laid one or more batches. Later workers confirmed this method for distinguishing nulliparous from older,

parous females in some other anopheline species; Davidson[2] elaborated the principle on a statistical basis to derive a daily survival-rate for *A. gambiae*. New departures were made by Gillies in the recognition of young females (pre-gravids) of this species on the basis of partial ovarian development only after their first blood meal[3], and by the presence of a mating plug in the common oviduct[4]. The undoubted value, and also limitations of these, and certain other methods, for determining the longevity of mosquitoes are indicated by Macdonald[5] in his analysis of factors in the epidemiology of malaria. It may be emphasized here that none of these methods is suitable for telling the actual age of the individual mosquitoes making up the older, parous group. This leaves much to be desired. Thus, in favourable climatic conditions nullipars are generally no more than about two or three days old; parous females may be only a day or so older or have lived nearly as long as, or longer than, the extrinsic period of the parasites they may happen to harbour, usually a period of 10–14 days. The last may be actively transmitting the disease, the others may yet survive to do so. In mosquito control work, it would be invaluable to be able to determine with considerable accuracy the age of any individual mosquito caught in the control area. This would be particularly convenient in the early detection of individuals resistant to insecticide in a surviving mosquito population of very low density. It would also be relevant to checking the efficacy of control in the earlier phases of an eradication scheme or where, for various reasons, it may only be practicable to prevent transmission by reducing mosquito longevity to less than the extrinsic period of the pathogen. Apart from practical issues of this kind, accurate age determination of individual mosquitoes would be of immense interest in purely biological studies on their behaviour.

Recently, there have been notable developments towards a solution to this problem. Russian workers, in fact, made important progress in this direction nearly a decade ago. Several months ago, Dr. M. T. Gillies prepared translations of papers published by Polovodova[6] and Detinova[7] in 1949, advance copies of which he kindly made available to us, and others. The Russian work showed for *Anopheles maculipennis* that when an egg passes from its follicle at oviposition it leaves behind a corpus luteum in the form of a dilatation of the tube connecting the ovariole to the lumen of the oviduct in the ovary. This persists through subsequent gonotrophic cycles, each of which in turn is marked by a residual corpus luteum. Thus, the number of these corpora lutea in an ovariole indicates the number of gonotrophic cycles completed by the mosquito. If the duration of a cycle is known, it is then possible to tell the age of the individual mosquito with considerable precision. Some ovarioles do not produce an egg in every cycle, so that the maximum number of corpora lutea per ovariole must be noted. A fuller account of the Russian work has been prepared by Gillies[8]. Recent independent studies by Colless[9] on certain Malayan culicines seem to demonstrate the same criterion for age determination in three species of *Culex* and in *Aedes albopictus*. Lewis[10] reports some preliminary observations on the ovarioles of *A. gambiae* but does not develop the subject beyond the recognition of nulliparous from parous females.

Species of *Mansonioides* are among the mosquitoes of medical importance, primarily as vectors of filariasis of man in the Oriental region, but with some implications also as possible vectors of yellow fever and other viruses. They can be a severe biting nuisance. Their role as vectors of parasites and disease to animals, and possibly man, may well be shown in future to be greater than is generally accepted at present. Colonies of several species of *Mansonioides* have been maintained in our laboratory for about three years using the methods of Laurence and Smith[11]. It was convenient and of interest, therefore, to examine the possibility of determining the age of individual *Mansonioides* females by a count of their corpora lutea, as described for *A. maculipennis* and suggested for *Culex* and *Aedes*. This article reports that in the *Mansonioides* mosquito a corpus luteum remains to mark each gonotrophic cycle and that the maximum number of corpora lutea found in the ovarioles of its ovaries is a valuable index to the actual age of the mosquito.

The experiments demonstrating this were, briefly, as follows: adult mosquitoes were kept in 25 cm. cube cages of wood frame and plastic netting at 26–30° C., humidity within the cages being maintained by damp lint on top of the cages, which were also draped with a thin polyethylene case. Except when being starved before a blood meal, the adults had access in their cages to cut apple and to sugar solution in cotton-wool. Females were fed on blood by inserting the human hand inside a cage. They first fed readily three days after emergence. Gorged females were transferred to a separate cage, as described, and became gravid four days later. When removed to large beakers containing water and floating *Salvinia*, they oviposited on the plant almost at once. In these experiments, a second blood meal was given within 12–18 hr. of oviposition. The second gonotrophic cycle was completed in four days. This procedure was continued with *Mansonioides uniformis* and *M. annulifera* through, respectively, six and three cycles, and representative females were dissected at suitable intervals for ovariole structure. The ovaries were dissected out in 0·9 per cent saline. Ovarioles were then released by breaking the membrane investing the ovary with a fine needle and teasing the tracheal supply aside carefully. With some practice, the corpora lutea could be exposed with considerable ease and counted under a stereoscopic microscope magnifying at × 30.

Results are given in Table 1, and illustrated in Figs. 1 and 2. Fig. 1 shows the germinal area, first follicle and simple pedicel in the ovariole of a three-

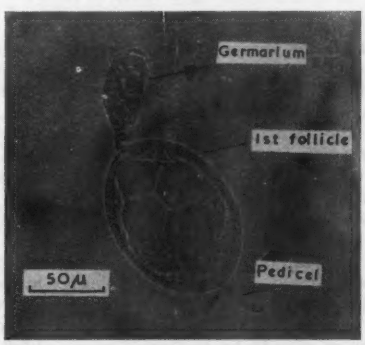

Fig. 1. Ovariole of 3-day old nulliparous *M. uniformis*

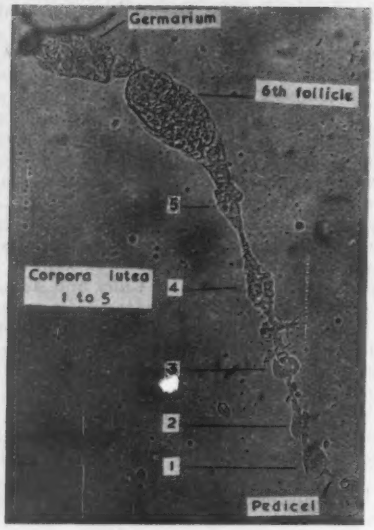

Fig. 2. Ovariole of 23–24-day old parous *M. uniformis*, after five gonotrophic cycles. (Magnification as Fig. 1)

day-old, unfed *M. uniformis* female. Fig. 2 is an ovariole isolated from the ovary of a 23–24-day-old female of *M. uniformis* after five blood meals and ovipositions had been completed. The five corpora lutea each represent a gonotrophic cycle lasting about four days and the first blood meal was given when the mosquito was three days old. Agreement is very close indeed between the actual known age of this individual and the calculated age, based on the number of corpora lutea found and the time required for each gonotrophic cycle. Other individuals killed earlier in the series and with fewer gonotrophic cycles completed showed corresponding maximum numbers of corpora lutea in the ovarioles. Similar results were obtained with *M. annulifera*. These results demonstrate for *Mansonioides* findings similar to those reported for *A. maculipennis*, *Culex* spp. and *Aedes albopictus*. This method of telling the age of any individual mosquito seems, therefore, likely to be widely applicable in mosquitoes generally. It promises to be of great value in elucidating problems in mosquito behaviour, either natural or under pressure of control.

Table 1. Showing, for *M. uniformis*, the Maximum Number of Corpora Lutea in an Ovariole in Relation to the Experimentally Known Age and Physiological State of the Mosquitoes

	Maximum number of corpora lutea in an ovariole	Age of females in days
Emerged and unfed	0	3
After first oviposition	1	7–8
After second oviposition	2	11–12
After third oviposition	3	15–16
After fourth oviposition	4	19–20
After fifth oviposition	5	23–24
After sixth oviposition	6	27–28

Acknowledgment is made to Mr. S. A. Smith of this Department for the photographs.

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INDUCTION OF RESPIRATORY DEFICIENCY IN YEAST BY MANGANESE, COPPER, COBALT AND NICKEL

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Among the chemical agents which induce respiratory deficiency in yeasts, acriflavine[1], triphenyl tetrazolium chloride[2], *p*-nitrophenol[3], and propamidine isethionate[4] are especially effective in producing the deficiency in a large fraction of the surviving population. The present work is a survey of the efficacy of various metallic salts in inducing respiratory deficiency.

Respiratory-sufficient yeasts containing fewer than 1 per cent respiratory-deficient cells when grown under normal conditions were chosen from the Lindegren breeding stocks. Efficacy in inducing respiratory deficiency (during growth) was tested by growth in the following nutrient medium (to which the various agents to be tested were added later): magnesium sulphate ($MgSO_4.7H_2O$), 0·5 gm.; potassium dihydrogen phosphate, 1 gm.; ammonium sulphate, 1·5 gm.; 'Bacto' peptone, 1·8 gm.; 'Bacto' yeast extract, 2 gm.; glucose, 10 gm.; U.S.P. agar, 20 gm. dissolved in 1,000 ml. of water. Concentrated stock solutions of the various agents (usually 2·5 per cent) were sterilized separately and added to the medium at temperatures around 50° C.

Respiratory deficiency was scored by the triphenyl tetrazolium chloride-overlay method[5]. (1 mgm./ml. of triphenyl tetrazolium chloride was dissolved in molten 1·5 per cent 'Bacto' agar adjusted to *p*H 7·0 with *M*/15 phosphate mixture, cooled to 50° C., gently poured over the diagnostic plate cultures and incubated at 30° C. Respiratory-sufficient colonies turn dark red within an hour while respiration-deficient colonies remain white.) Medium for the

Table 1. The Induction of Respiratory Deficiency by Manganous Sulphate

Culture	Concentration (per cent)	Standing culture 200 ml. 24 hr. Per cent aer	Standing culture 200 ml. 24 hr. Per cent variegated and sectored	Standing culture 200 ml. 48 hr. Per cent aer	Standing culture 200 ml. 48 hr. Per cent variegated and sectored	Shaken culture 200 ml. 24 hr. Per cent aer	Shaken culture 200 ml. 24 hr. Per cent variegated and sectored	Shaken culture 200 ml. 48 hr. Per cent aer	Shaken culture 200 ml. 48 hr. Per cent variegated and sectored	Nitrogen-starvation medium. Standing cultures 50 ml. 24 hr. Per cent aer
14061 (Haploid)	0·06	< 1	0	< 1	0					< 1
	0·12	< 1	0	< 1	0					2
	0·17	39	15	39	21	27	24	6	7	4
	0·33	56	26	64	21	25	18	4	4	3
F-2 (Diploid)	0·06	< 1	0	< 1	0					< 1
	0·12	< 1	0	< 1	0					1
	0·17	52	10	77	6	8	17	10	6	1
	0·33	64	22	95	5	56	21	98	2	5
11294 × 11296 (Tetraploid)	0·66	< 1	0	< 1	0					< 1
	0·12	< 1	0	< 1	0					6
	0·17	69	11	95	3	33	23	14	4	8
	0·33	76	21	98	2	52	19	80	8	13

diagnostic plates was double-strength, except for glucose and agar, as compared with the medium containing the various agents. (The medium on the diagnostic plates was that ordinarily used in this laboratory, while the medium containing the salts was half-strength except for agar and glucose. Preliminary experiments had revealed that 'diluted' medium produced more deficient variants than full-strength medium.)

Treatments in liquid media were carried out in 20 ml. of medium in 50-ml. Erlenmeyer flasks, or 40 ml. of medium in 200-ml. flasks. Cells were sampled for inoculation on the diagnostic plates, usually after incubation for about 24 or 48 hr. at 30° C. Ammonium sulphate, peptone and yeast extract were omitted from some media, which were designated 'nitrogen-starvation' media.

Rapid surveys were achieved with gradient agar plates[6] containing the agent to be tested in the upper layer. Heavy suspensions of 1-day-old cultures were streaked on gradient plates and incubated for 48 hr. The streaks faded out gradually (instead of ending abruptly) after the range of confluent growth. In seeking to determine the effects produced on the Szybalski plates, cells were sampled from the intermediate region and spread on diagnostic plates after adequate dilutions.

Three strains, 14061 (haploid), *F*-2 (diploid) and 11294 × 11296 (tetraploid), were inoculated in liquid media supplemented with various concentrations of manganous sulphate and allowed to proliferate. When samples were diagnosed for respiration deficiency, red (sufficient), white (deficient) and sectored or variegated colonies appeared. The sectored colonies were red colonies with usually three or more white sectors; the variegated colonies had a dark red centre and white periphery, suggesting delayed response in the change from respiratory sufficiency to deficiency. Concentrations below 0·12 per cent were ineffective in inducing respiratory deficiency (Table 1). Nitrogen-starvation medium yielded very few deficiencies.

Manganous chloride was found to produce the same effect as manganous sulphate.

Manganous sulphate is only slightly toxic to yeasts. The survivors of the tetraploid culture (11294 × 11296) (spread on plates containing 0·17 and 0·33 per cent manganous sulphate) were 85 and 48 per cent, respectively. Colonies grown on manganese agar suspended in water and spread on diagnostic plates were found to contain approximately the same percentages of respiratory-deficient cells as similar cultures grown in liquid media containing manganese.

To test the possibility that respiratory-deficient cells may have a competitive advantage over respiratory-sufficient cells in medium containing manganous salts, cells were picked up by a micromanipulator from a 1-day-old tetraploid (11294 × 11296) culture in standard medium and transferred separately to standard and 0·17 per cent manganous sulphate agar and allowed to proliferate for 72 hr. Of twenty cells transferred to manganous sulphate agar, thirteen formed colonies. Samples from suspensions of those colonies contained 45–65 per cent respiratory-deficient cells. Eighteen colonies formed on normal agar (two out of twenty failed to grow) contained less than 1 per cent respiratory-deficient cells. It may be inferred that each colony started from a single respiratory-sufficient cell and produced respiratory-deficient cells at high frequencies during proliferation in the presence of manganous sulphate. The frequent occurrence of sectored and variegated colonies (which generally decrease with time) also supports the view that induction has occurred.

Growth of the respiratory-sufficient diploid (*F*–2) culture was followed in 50-ml. flasks in the presence and absence of manganous sulphate. A respiratory-

Table 2. Percentage of Respiratory-Deficient Colonies (among the Survivors) after Growth in Media containing Cobaltous Chloride, Nickelous Chloride and Cupric Sulphate
Standing cultures in 50-ml. flasks. Sampled at 24 hr. *K* indicates no survivors

Concentration (per cent)	14061 (Haploid)	*N*560 (Haploid)	*N*579 (Haploid)	*F*-2 (Diploid)	11294 × 11296 (Tetraploid)
$CoCl_2.6H_2O$					
0·013	33	< 1	< 1	< 1	< 1
0·025	100	< 1	2	20	< 1
0·038	100	95	5	90	11
0·050	*K*	*K*	*K*	*K*	*K*
$NiCl_2.6H_2O$					
0·013	< 1			< 1	< 1
0·025	< 1			< 1	< 1
0·038	< 1			< 1	< 1
0·050	46			53	65
0·075	*K*			*K*	*K*
$CuSO_4.5H_2O$					
0·006	7	< 1	< 1	4	13
0·013	*K*	1	4	17	*K*
0·025		86	71	*K*	
0·038		*K*	*K*		

deficient culture derived from the same strain (by treatment with manganese) was tested in parallel. The respiratory-sufficient culture grew slightly better than the respiratory-deficient one in the absence of manganese. The respiratory-sufficient culture in the presence of manganese produced many deficient cells, but a large fraction of respiratory-sufficient cells persisted indicating that respiratory-deficient cells do not have an overwhelming relative advantage. The respiratory-deficient culture was slightly inhibited in the presence of manganese.

Cupric sulphate ($CuSO_4.5H_2O$), cobaltous chloride ($CoCl_2.6H_2O$) and nickelous chloride ($NiCl_2.6H_2O$) are more toxic than manganous salts, but sublethal concentrations led to the production of the respiratory-deficient cells (Table 2). The cultures differ markedly in sensitivity to copper, and the results suggest that more respiratory-deficient variants are produced by resistant cultures than by sensitive ones.

Sodium chloride, potassium chloride, lithium chloride and strontium nitrate are much less toxic than copper, cobalt and nickel. Growth of haploid culture 14061 and tetraploid 11294 × 11296 was suppressed by 5·8 per cent sodium chloride, 7·4 per cent potassium chloride and 0·25 per cent lithium chloride. Strontium nitrate up to 0·6 per cent did not inhibit growth (higher concentrations could not be tested because of the formation of a precipitate). Even at concentrations which suppressed growth most of the inoculum survived after two days. Samples from treated flask cultures did not show any increase (over controls) in the frequency of the respiratory-deficient cells.

The inhibitory concentrations of mercuric chloride, potassium dichromate and arsenic acid were, respectively, 0·005 per cent, 0·01 per cent, 0·05 per cent. No increase in the frequency of the respiratory-deficient cells (above controls) was detected either in liquid medium or on gradient plates. This may be because the high toxicity did not permit sufficient growth for the expression of the phenomenon. Cultures grown in the presence of arsenic acid produced many dwarf colonies but were all red under the triphenyl tetrazolium chloride-overlay.

Respiratory deficiency in yeast may be the result either of destruction or inactivation of a cytoplasmic granule or mutation of a gene. Ephrussi[1], Laskowski[2] and Yanagishima[3] have shown that this condition may be induced with high frequency during growth by different organic poisons. The inorganic ions manganese, copper, cobalt and nickel induce respiratory deficiency in yeasts with high frequency. The high frequency of induction and the relative independence of ploidy suggests that most of the respiratory deficiencies induced by these ions are due to the destruction or inactivation of cytoplasmic granules rather than to effects on the genome. The alkaline earths, sodium, potassium, lithium and strontium, seem incapable of inducing respiratory deficiency. Mercury and arsenic failed to reveal any increase in respiratory deficiency above controls, but this may be due to their extreme toxicity.

Manganous salts were very slightly toxic, but induced respiratory deficiency with great efficacy. Demerec[7] classified manganous salts as 'very mutagenic' because of their mutagenic (?) effect on *Escherichia coli*, but the effect of manganous salts on yeasts seems to be due almost exclusively to their effect on cytoplasmic granules rather than on the genome.

It is commonly said that most mutagens (meaning agents which cause gene mutation) are carcinogens, and it has been inferred that the problem of cancer is related in some way to the structure of the deoxyribonucleic acid. This inference rests on the assumption that gene mutation is an important factor in carcinogenesis. Many of the effects, however, which are ascribed to gene mutation may be due to the damage to the autonomous cytoplasmic granules, and such carcinogens as ultra-violet and X-rays have often been demonstrated to produce stable variations in the extra-chromosomal apparatus. Re-evaluation of ideas relating gene mutation to carcinogenesis may be in order.

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Note added in proof. Caffeine at concentrations of 0·2 per cent was similarly found to be highly efficacious in the production of respiratory deficiency.

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DIRECT OBSERVATION OF DISLOCATIONS IN GRAPHITE

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RECENT electron microscopy work has revealed the presence of dislocations in graphite. The nature of these dislocations and their movement within the structure of the crystals have been studied and recorded by means of motion pictures. Many of the features of dislocation arrangement and motion described by Hirsch, Horne, Whelan and Bollman for aluminium[1] and stainless steel[2] have been observed also in the case of graphite. Single dislocations occur within crystal grains, line up to form sub-grain boundaries, form dislocation networks (square and hexagonal cross-grids), and are spontaneously generated at crystal edges. Examples of sub-grain boundaries (small-angle misfit boundaries) formed from aligned single dislocations are shown at *A* and *B* in Figs. 2*a* and 2*b*. An example of cross-grid dislocation networks is exhibited in Fig. 1*a*. These photographs and the others to be discussed were taken from the motion picture sequences and have not been retouched.

Sub-grain boundaries and cross-grids have been observed to undergo modification under thermal stress. They move about and undergo rearrangement and in some cases disappear completely after a time. The pinning of sub-grain boundaries by an obstacle in the graphite structure has been observed and photographed. As the obstacle was encountered, the motion of a section of the aligned dislocations making up the sub-grain boundary was slowed and brought almost to a complete halt. This resulted in a bowing of the sub-grain boundary. The nature of the obstacle was not determined.

To illustrate the above description, comparison of Figs. 1*a* and 1*b*, which are taken from the same motion picture scene but over an interval of time, demonstrates the alteration and almost complete disappearance of the cross-grid dislocation network. Next, study of Figs. 2*a*, *b* and *c* shows how sub-grain boundary *A* moves across the crystal from its position at the left in Fig. 2*a* to an intermediate position in Fig. 2*b*, and finally in Fig. 2*c* occupies the place originally devoted to the dislocation array *B*. This sequence of pictures also demonstrates the pinning and bowing of dislocations around an obstacle. The dislocation array *B* is seen in Fig. 2*a* to have been pinned at point *C* by some unidentified obstacle, and bowing has occurred. In Fig. 2*b* the bowed section of *B* is seen to have passed the pinning point and broken up into individual dislocations, which travel at right angles to the original direction of motion. The final picture of the sequence, Fig. 2*c*, shows that

Fig. 1. Sequence of photographs taken from the motion picture film showing the alteration and almost complete disappearance of a hexagonal cross-grid dislocation network. (*a*) The network in early time under the microscope; (*b*) the same field at a later time. (Magnification of all illustrations is × 12,500; the distance between the black line markers is one micron)

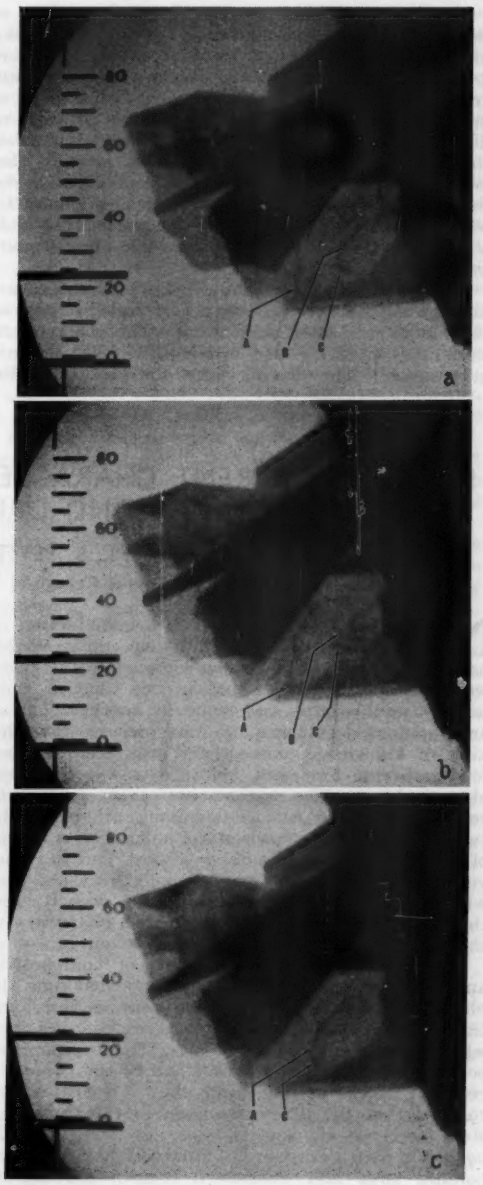

Fig. 2. A sequence taken directly from the motion pictures showing movement of aligned single dislocations forming the sub-grain boundary at *A* in (*a*) to an intermediate position in (*b*), to occupy finally the space originally devoted to dislocation array *B* in (*c*)

This sequence of photographs also demonstrates a pinning point at *C*. In (*a*), array *B* is pinned and bowed around an obstacle at *C*, while in (*b*) the bowed section has passed the pinning point by breaking up into individual dislocations, which travel at right angles to the original direction of motion; (*c*) shows that dislocation array *B* has disappeared by moving out of the crystal and array *A* has moved into this area, has encountered the same obstacle at *C* as array *B* did originally and, as a result, has begun to bow

dislocation array *B* has disappeared by moving out of the crystal and dislocation array *A* has moved into this area, has encountered the same obstacle at *C* as array *B* did originally and as a result has begun to bow.

Dislocation motion can be classified as fast or slow. The fast motions consist of a rapid jerky motion, while the slow motions involve a more gradual drifting of the dislocations across a crystal grain. Under the electron microscope, the speed of motion of the black lines indicating the presence of dislocations appears to differ depending upon whether the area of strain is associated with a single dislocation or a network of dislocations. In addition, the speed of motion presumably is determined by whether glide or climb occurs. It appears that glide is characterized by rapid motion while climb results in a slow drifting motion.

Only a brief description of the techniques and findings is given here because it is intended to present these fully in a later publication. The observations were made at 80 kV. in a Norelco *EM* 100*B* electron microscope. The driving force for producing dislocation motion was supplied by the thermal stresses set up by the electron beam. Sample preparation was simple. Natural graphite crystals were placed between two glass microscope slides and sheared by sliding one plate over the other. This action was sufficient to produce small fragments of cold-worked material. These fragments were mounted on a 200-mesh copper specimen screen by rubbing the particles into the screen. The crystals lie on the basal plane, normal or nearly so to the direction of the electron beam. Here and there are thin sections permitting ready observation by transmission of the dislocations as well as other features of the graphite structure. The motion pictures were taken by photographing the fluorescent screen of the electron microscope, operated at 12,500 and 25,000 magnification, by means of a 16-mm. Bell and Howell 70*J* camera, Angénieux *f*/0·95 lens of 1 in. focal length using Tri-*X* film at 16 frames per sec.

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FURTHER INHERENT CHARACTERS OF PLANT SPECIES OF WETTER AND DRIER HABITATS

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NOT many centuries after the introduction of alphabetic script, Theophrastus[1] employed this handy medium to record how some species of plant were characteristically found in one kind of community and habitat and some in another. From anthropological evidence, we may presume that this kind of knowledge existed, and was used, by our food-gathering forebears, before even the inception of agriculture. The systematists of the nineteenth century, and the ecologists among others of the twentieth[2], have emphasized the point with a wealth of necessary and erudite observations. But in future years the question will progressively be asked, not where does a species grow, but why does it grow there; the question of what inherent characters of the plant suit it to such and such an environment[3–6].

The answer must be in terms of comparative anatomy and comparative physiology, including the physiology of growth and development, as describing that genotypic variation among different species upon which ecological selection acts. The comparative ecological anatomy of the first half of the twentieth century[3,5] gives us important clues. But it is now realized that the differences seen in the transverse stem sections of, say, *Ranunculus acris* and *R. aquatilis*, each grown in their natural habitats, may contain large and unassessed components due to induced modification, and that the nature and magnitude of the inherent genotypic difference has, in most such cases, never yet been experimentally determined[7]. The same applies to many earlier observations in comparative physiology[8]. Fresh and more critical comparisons are required between individuals of ecologically contrasting species which have been reared in the same environment.

A useful method of reducing random variation, in such comparisons, is to compare a pair of species which are similar in general structure as well as in seasonal behaviour, such as two species of the same genus[7]. A recent communication[8] describes such an investigation of pairs of species in six genera. In each case, individual plants of an ecologically wetter-living species were reared together with plants of a related drier-living species in a common environment. So far, the behaviour of only one character has been reported; but it is the present purpose to give a very condensed summary of the behaviour of twenty characters. It is expected that this type of investigation may soon become commoner, since it is both of fundamental importance and of agricultural utility. The pairs of species compared are given in Table 1.

Table 1. Pairs of Ecologically Contrasted British Species, which are Compared after being Reared in a Common Environment

Genus	Wetter-living species *W*	Drier-living species *D*
Ranunculus	*R. flammula*	*R. bulbosus*
Hypericum	*H. tetrapterum*	*H. perforatum*
Primula	*P. vulgaris*	*P. veris*
Veronica	*V. beccabunga*	*V. chamaedrys*
Centaurea	*C. scabiosa*	*C. nemoralis*
Poa	*P. fluitans* = *Glyceria fluitans*	*P. annua*

Rather than list all the 240 numerical values, only the direction of the deviation need be given, as in Table 2. Taking in each case the value for the drier-living species as a basis, a plus sign indicates that the wetter-living species is found to have a higher value for the particular character; a minus sign, that the wetter-living species has a lower value; and a nought, that no difference is reported. Thus the signs are those of (*W*–*D*).

Table 2. INTRAGENERIC COMPARISONS, FOR TWENTY CHARACTERS, WITHIN PAIRS OF SPECIES IN SIX GENERA

A plus sign indicates that the wetter-living species of the pair has the higher numerical value for the character concerned. The differences considered are inherent genotypic differences, induced modification having been neutralized (ref. 9)

Characters compared intragenerically	*Ranunculus*	*Hypericum*	*Primula*	*Veronica*	*Centaurea*	*Poa*	Association between magnitude of character and wetness of natural habitat
Section 1. Characters of lamina							
(*a*) Fresh weight	−	−	+		+	+	
(*b*) Water weight	−	−	+		+	+	
(*c*) Dry weight	−	−	−		−	+	? − ve
(*d*) Thickness	+	−	+	+	+	+	? + ve
(*e*) Degree of development of transpiring surface	−	+	−	−	−	−	? − ve
(*f*) Number of cells, estimated	−	−	−		+	−	? − ve
Section 2. Characters of palisade cell							
(*g*) Volume, and weight	+	−	+	+	−	+	
(*h*) Water weight	+	−	+	+	−	+	
(*i*) Dry weight	+	−	+	+	−	+	
(*j*) Chromosome number (refs. 2, 10)	+	−	0	−	−	+	
Section 3. Characters of lamina, inflected							
(*k*) Fresh weight/chromosome number (C.N.)	−	+	+		+	+	? + ve
(*l*) Water weight/C.N.	−	+	+		+	+	? + ve
(*m*) Dry weight/C.N.	−	+	−		+	+	
(*n*) Thickness of lamina/C.N.$^{1/3}$	−	+	+	+	+	+	? + ve
(*o*) Cell number estimate/C.N.	−	+	−		+	−	
(*p*) Cell number estimate × C.N.	−	−	−		−	+	? − ve
Section 4. Character of lamina and cells							
(*q*) Dilation, being fresh weight/dry weight	+	+	+	+	+	+	Sig. + ve
Section 5. Characters of palisade cell, inflected							
(*r*) Volume, or weight/C.N.	+	+	+	+	+	+	Sig. + ve
(*s*) Water weight/C.N.	+	+	+	+	+	+	Sig. + ve
(*t*) Dry weight/C.N.	+	+	+	+	+	+	Sig. + ve

For a large number of inherent characters, as is of course to be expected, there is no consistent association reported between magnitude of character and humidity of natural habitat. These characters are clearly not, as such, strongly selected by ecological wetness and dryness. This group includes the characters *a*, *b*, *g*, *h*, *i*, *j*, *m* and *o* of Table 2. But these serve as a foil to those other characters, the magnitude of which is more critical for success in wetter or drier environments.

A second group of characters may be distinguished, where there is a preponderant but not invariable relationship. Thus, the wetter-living species of a pair usually, though not always, differs inherently by having: (*c*) less dry weight of lamina; (*d*) greater thickness of lamina; (*e*) a lower degree of development of transpiring surface; (*k*) a higher ratio of lamina fresh weight to cell chromosome number; (*l*) a higher ratio of lamina water content to cell chromosome number; (*n*) a higher ratio of lamina thickness to cube root of cell chromosome number; besides (*p*) a smaller total number of chromosomes in the lamina, as obtained by multiplying the estimate of number of lamina cells by the number of chromosomes in each cell; (*f*) often a smaller number of cells per lamina. With regard to (*e*), this result is in opposition to the views of Huber[11,3]; but his generalization does, of course, apply to the distinction between night-feeding succulent xerophytes and non-succulent mesophytes.

With a third group of characters (sections 4 and 5), the deviations are here found to be invariably in the same direction, which seems to reflect rigorous direct or indirect selection of these inherent characters by ecological wetness or dryness. Thus, in the six genera concerned, the wetter-living species has inherently: (*q*) greater dilation of the lamina and its constituent cells; while its palisade cells, which with regard to size are interspecifically proportional to the average leaf cells[12], have (*r*) greater cell volume per chromosome; (*s*) greater cell water content per chromosome; (*t*) greater cell dry weight per chromosome.

While Maximov[3] did give some experimental evidence that non-succulent species of drier places usually have an inherently higher vacuolar osmotic pressure[13], he did not, in our opinion, prove that they had inherently smaller cells—as he considered he had done[14]—since his chain of argument contains the weak link of Le Chatelier's theorem applied quite out of context. The present investigation shows that in one third of the genera studied the drier-living species has, in fact, the larger cells, cells sometimes of nearly double volume. The issue has been bedevilled by polyploidy. But thanks to the collateral progress of nuclear cytology[10,2], it can now be unscrambled. Thus, for the material here studied, we can at least definitely state that the drier-living species have inherently in their laminas (i) drier cells, and (ii) cells which have a smaller volume per chromosome.

Without dealing with the various other points which arise, a picture begins to emerge of the selection by ecological dryness of genotypes with the following characters: less dilate and usually thinner laminas, but which usually contain a greater dry weight, a greater number of cells and a greater total number of chromosomes; and less dilate cells, in which each chromosome is associated with a smaller amount of dry matter and water and a smaller cell volume—cells in which unit dry weight contains apparently a higher proportion of genes.

It is perhaps not inappropriate to find it reported that these species of intrinsically less-favourable habitats have cells which are relatively the better equipped with molecular-level 'machine-tools'; while in moister habitats other species, less heavily equipped, are able to displace them. On a rough analogy, the maintenance workshops and equipment which supported Sir Vivian Fuchs's crossing of Antarctica would be out of place in a walking tour along the Pennines.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

β-Globulin Variants in Man

Using starch-gel electrophoresis, Smithies has discovered several β-globulin patterns in human plasma. He refers to these as βC, βBC, βCD and βD[1,2]. βC is the type most commonly found, but βBC occurred in about 1 per cent of Canadians and βCD in about 4 per cent of American Negroes and even more frequently in Australian Aboriginals. The formation of the different β-globulins *B*, *C* and *D* appears to be genetically controlled and Smithies suggests that each may be determined by one of three allelic genes.

In a search for such β-globulin types we have recently encountered four unusual patterns. The starch-gel electrophoresis was carried out on plasmas to which hæmoglobin had been added to saturate the haptoglobins, using the discontinuous buffer system of Poulik[3]. Under these conditions the β-globulin region is clear of either the hæmoglobin – haptoglobin complexes or free hæmoglobin (Fig. 1) and it is possible to pick out unusual β patterns in one-dimensional separations. The unusual plasmas were further subjected to two-dimensional paper/starch-gel electrophoresis[4] to confirm the identification of the new components as β-globulins.

In a series of 153 Africans from Gambia we observed four individuals who had, besides β-globulin *C*, a slower moving β-globulin component which was present in about the same amounts as β-globulin *C*. In one of these individuals, however, the unusual β-globulin component had a distinctly slower mobility than that found in the other three. Thus two distinct β-globulin variants appeared to be present in this African population, and since it is probable that one of these corresponds to the β-globulin *D* of Smithies we will refer to them for the present as β-globulins D_1 and D_2 (Fig. 1).

In a series of 139 English people no example of phenotypes βCD_1 or βCD_2 was observed. However, two individuals were encountered with an unusual β-globulin component moving faster than β-globulin *C*. In both, the new component was present along with, and in about equal amounts to, β-globulin *C*. The mobility of the new fast-moving component was, however, different in the two individuals (Fig. 1). Since one of them probably corresponds to Smithies' β-globulin *B* we will refer to these two new components as β-globulins B_1 and B_2.

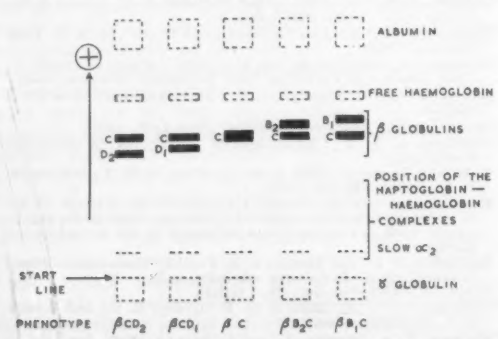

Fig. 1. Relative mobilities of β-globulin variants in human plasma. (Starch-gel electrophoresis with the discontinuous buffer system of Poulik)

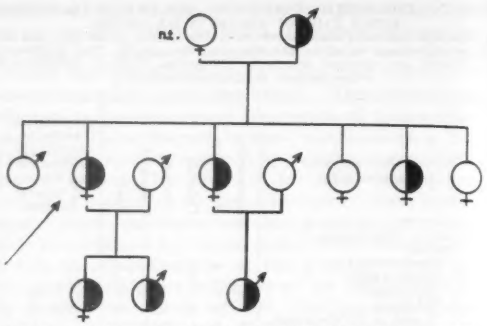

Fig. 2. Pedigree of family *W*. β-globulin phenotypes: ○, βC; ◑, βB_1C; *n.t.*, not tested

Among the relatives of the individual with phenotype βB_1C six further individuals were encountered with the same phenotype. The pedigree is shown in Fig. 2, and it seems reasonable to infer that the formation of β-globulin B_1 is genetically determined and that the individuals in this family with the βB_1C phenotype are heterozygous for the appropriate gene.

So far it has not been possible to carry out family studies on any of the other variants observed. However, these results, combined with those of Smithies[2], suggest that a whole series of genetically determined β-globulin variants can occur and the situation may well prove to be analogous to that found with respect to the genetically determined hæmoglobin variants which have been so extensively studied in recent years.

We would like to thank Dr. J. Humphries, who kindly put at our disposal the samples from the population in Gambia.

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High Resolution of Human Plasma Components by Starch Gel Electrophoresis

With one-dimensional starch gel electrophoresis, the following experimental procedure allows the separation of human plasma into a large number of components.

The gel is poured into 'Plexiglas' trays (internal dimensions 370 mm. × 50 mm. × 20 mm.). The sample (a mixture in equal parts of plasma and 30 per cent soluble starch in 0·025 *M* borate buffer) is applied in a slot, 40 mm. × 2 mm. Electrical connexion with the ends of the gel is obtained by means of thick filter paper ('Cofram' *MAB C* 3).

A potential of 450 V. is applied for 18 hr. at +4° C. After electrophoresis, the gels are fixed in

5 per cent acetic acid and stained with aqueous amido-black (amido-black 10 *B*, 1 gm.; 1 *M* acetic acid, 500 ml.; 0·1 *M* sodium acetate, 500 ml.). The gel is then washed with 5 per cent acetic acid.

The electrophoretic pattern obtained with a haptoglobin type 2 (*Hp* 2) human plasma is shown in Fig. 1; on the cathodic side of the slot, two γ-globulin zones; on the anodic side, from the slot towards the albumins, first are seen two zones, one being a β-lipoprotein (which stains with sudan black); then the $S\alpha_2$-globulin band, then nine strips between the $S\alpha_2$- and the βc-globulin, three of them being characteristic of *Hp* 2–1 and *Hp* 2–2 groups; then βc-globulin, one or two $F\alpha_2$-globulins, five strips between the fast α_2 and the albumin border and finally albumin.

Fig. 1

The recent results obtained by Poulik and Smithies[1] with two-dimensional starch gel electrophoresis define the nature of the zones we have just described. We believe that among the five strips between the albumin and the fast α_2-globulins some correspond to the α_1-globulins (α_1A or α_1B).

The βc globulins are preceded by a zone which may be a β component (β*A* or β*B*).

Besides this large tray technique we have used a standard method involving smaller 'Plexiglas' trays (internal dimensions 234 mm. × 80 mm. × 6 mm.) for the study of different protein solutions. Two samples are applied in two slots (28 mm. × 2 mm.) and allowed to migrate simultaneously, side by side, in the same tray for 18 hr. with a 140 V. potential. Electrophoretic patterns under these conditions are similar to those obtained by Smithies[2]; however, the γ-globulin zone is distinctly divided into two components. In macroglobulinæmia an increase in the fast or the slow component can occur.

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A New Method for resolving Amino-acids by Metabolism of Bacteria on Benzoyl Derivatives of DL-Amino-acids

While engaged in the study of metabolism and hydrolysis by soil bacteria of benzoic acid derivatives, amino-acids, and acylated amino-acids[1–4], we noticed that soil bacteria *KT* 231 and *KT* 233 have the metabolic activity shown in Table 1. The constituents of the culture medium used in the experiments were as follows: NH_4Cl, 0·1 gm.; K_2HPO_4, 0·1 gm.; $MgSO_4.7H_2O$, 0·05 gm.; 1 per cent $CaCl_2.6H_2O$, 2 drops; 1 per cent $FeCl_3.6H_2O$, 1 drop; organic substance to be tested, 0·2 gm.; distilled water, 100 ml.; *p*H 7·4–7·6 (adjusted with 10 per cent sodium hydroxide).

Table 1

	KT 231	*KT* 233		*KT* 231	*KT* 233
Benzoic acid	+	+			
Dibenzoyl-DL-lysine	+	+	Benzoyl-DL-leucine	+	+
Dibenzoyl-DL-lysine (without NH_4Cl)	–	–	Benzoyl-DL-leucine (without NH_4Cl)	–	+
Dibenzoyl-D-lysine	–	–	Benzoyl-D-leucine	–	–
ε-N-Benzoyl-DL-lysine	–	–	DL-Leucine	–	+
Benzoyl-DL-phenylalanine	+	+	N-Benzoyl-DL-threonine	–	+
Benzoyl-DL-phenylalanine (without NH_4Cl)	–	+	N-Benzoyl-DL-threonine (without NH_4Cl)	–	–
Benzoyl-D-phenylalanine	–	–	N-Benzoyl-D-threonine	–	–
DL-Phenylalanine	–	+	DL-Threonine	–	–

+, Within four days at 25° C. there were luxuriant growths of bacteria on a culture medium with the particular organic compound as the source of carbon. This cultivation experiment was repeated three times in succession.
–, No visible growth of bacteria observed.

From the left column of Table 1, it is to be understood that *KT* 231 and *KT* 233 can utilize benzoic acid, which was produced from dibenzoyl-L-lysine by the action of their acylases, as the sole source of carbon. The ability of *KT* 231 to resolve dibenzoyl-DL-lysine was then tested as follows: *KT* 231 was grown at 25° C. in 100 ml. of the culture medium mentioned above containing 2·67 gm. of dibenzoyl-DL-lysine. After 3 days, the culture medium was adjusted to *p*H 4·5 with acetic acid, evaporated *in vacuo* to a small volume, acidified with dilute hydrochloric acid to *p*H 1·0, and extracted with ethyl acetate. From the aqueous layer, 0·80 gm. (85·0 per cent) of ε-N-benzoyl-L-lysine, m.p. 270–272° C. (decomp.), $[\alpha]_D^{20} = +19°$ was obtained. From the ethyl acetate layer, 1·08 gm. (81·5 per cent) of dibenzoyl-D-lysine, m.p. 145–146° C., $[\alpha]_D^{20} = +7·5°$ and 0·03 gm. (6·5 per cent) of benzoic acid, m.p. 118–120° C. were obtained.

In the same way, *KT* 231 metabolized benzoyl derivatives of DL-phenylalanine and DL-leucine to yield the following compounds respectively: L-phenylalanine, $[\alpha]_D^{18} = -35°$, benzoyl-D-phenylalanine, m.p. 139–140° C., $[\alpha]_D^{18} = -15°$ and L-leucine, $[\alpha]_D^{20} = +15°$, benzoyl-D-leucine, m.p. 103° C., $[\alpha]_D^{20} = +9·5°$. By the metabolism of *KT* 233, L-threonine, $[\alpha]_D^{20} = -28°$, and N-benzoyl-D-threonine, m.p. 145–146° C., $[\alpha]_D^{20} = -25°$, were obtained from *N*-benzoyl-DL-threonine in good yield.

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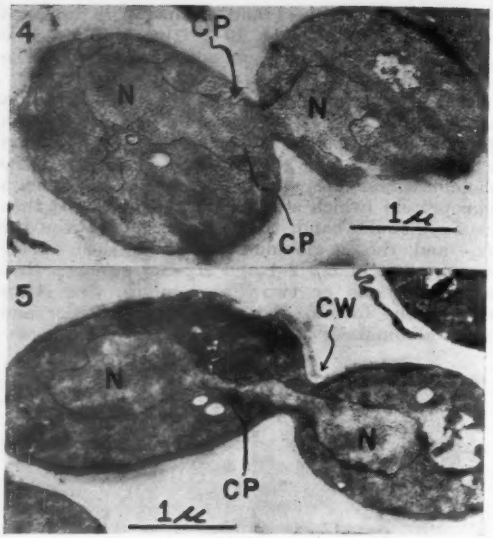
Nuclear Changes occurring during Bud-formation in *Saccharomyces cerevisiae* as revealed by Ultra-thin Sectioning

The lack of clarity prevailing among yeast cytologists as to the mode of budding in *Saccharomyces cerevisiae* tempted us to study this process by means of an improved ultra-thin sectioning technique. This technique has enabled us to observe nuclear behaviour during bud formation and subsequent division. Except for substitution of potassium permanganate for osmium tetroxide as the fixative, the method of preparing specimens for ultra-thin sections was exactly the same as previously reported[1,2]. A distillers yeast, *S. cerevisiae M*-1, was grown in a broth medium for several hours at 25° C. with aeration by means of vigorous shaking. The cells were collected by centrifugation and washed once with distilled water. The washed cells were then fixed in a 1·5 per cent aqueous solution of potassium permanganate at room temperature for 30 min. The time of fixation and concentration of permanganate were critical for preservation of internal cell structure. Explosion was minimized by prolonged treatment of the cells with cold partially polymerized *n*-butyl methacrylate. The sections were cut on a Porter–Blum microtome and observed in an *RCA* model *EMU-2b* electron microscope. Figs. 1, 2 and 3 show three parallel sections of a budding yeast cell. It is interesting that the conspicuous invagination of the dividing nucleus is situated a short distance away from the constricted cell wall of the bud. The difference in the

Figs. 1–3. A budding yeast cell. *N*, nucleus; *CP*, constriction point; *V*, vacuole; *CW*, cell wall



Figs. 4–5. Budding yeast cells at a later stage. Key as in Figs. 1–3

planes of constriction between the nucleus and the cell wall seems to be a routine occurrence and is considered characteristic of vegetative division in *S. cerevisiae*. This suggests that there is some mechanism which regulates the constriction of the nucleus at this point other than the simple pressure of the constricting cell wall. Close observation of these figures reveals that the constriction starts at certain points rather than being initiated uniformly around the site of constriction. The presence of the nuclear membrane throughout vegetative nuclear division implies that typical mitosis in *S. cerevisiae*, at least in the strict sense of the word, is lacking. Chromosomal figures which have been observed in the nuclei of the cells of higher organisms[3–5] have not been detected in either the nuclear vesicle or on the nuclear membrane during any stage of the nuclear division. Figs. 4 and 5 demonstrate somewhat later stages of nuclear division during bud-formation.

From the observations made in this study, we conclude:

(1) The nuclear membrane of *Saccharomyces cerevisiae* does not disappear during vegetative division. This favours the view that division of the nucleus during budding does not occur by a typical mitotic process.

(2) The nucleus of *Saccharomyces cerevisiae* undergoes an autonomous constriction during bud formation. Constriction of the nucleus does not coincide with constriction of the cell wall, but always occurs a little inside the mother cell.

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Heinz Bodies in Extravasated Erythrocytes

In many cases of toxic anæmia refractile granules, generally known as Heinz bodies, are formed in the red blood cells. These inclusions may be identified by their intense basophilia when stained supravitally; after fixation with alcohol they lose this property and as a result are not usually seen in Romanowsky-stained blood films. In these anæmias there is an associated fragmentation and distortion of the red blood cells.

A similar type of fragmentation and distortion of the red cells is sometimes seen in hæmothorax fluids, and this led us to examine the red cells by supravital staining with methyl violet. By this means Heinz bodies were demonstrated in the majority of serous and cystic fluids, and sometimes in bloodstained cerebrospinal fluid as well.

The inclusions show similar features to those of Heinz bodies formed in the circulating blood. They may be seen as refractile particles in unstained wet preparations and rapidly assume a dark purple-black colour when stained supravitally with 0·5 per cent methyl violet in normal saline. They vary in size from the minutest of dots to structures 3μ in diameter, and irregularly shaped forms may be seen as well as more rounded inclusions. An affected red cell may contain a single inclusion or a number (Fig. 1).

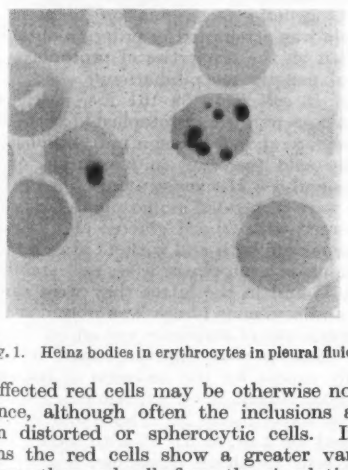

Fig. 1. Heinz bodies in erythrocytes in pleural fluid

The affected red cells may be otherwise normal in appearance, although often the inclusions are also found in distorted or spherocytic cells. In some specimens the red cells show a greater variety of appearances than red cells from the circulating blood in Heinz body anæmia.

Table 1 classifies 121 specimens from 100 patients, grading the extent of Heinz body formation in three categories.

In 15 cases more than one specimen was examined over a period of time. In six cases the proportion of cells containing Heinz bodies rose; for example, in a case of hæmothorax following mitral valvotomy there were 1·5 per cent 9 days after operation, less than 0·5 per cent at 24 days, 2 per cent at 28 days and 10 per cent 37 days following the operation. In one case an increase was later followed by a decrease; in seven cases no appreciable difference in the proportion of Heinz body containing cells was observed; and in two cases only a decrease was found.

Table 1

	Percentage of red cells containing Heinz bodies			
	>5·0	0·5–5·0	<0·5	Total
Pleural and peritoneal fluids	19	40	32	91
Cysts, hydroceles, joints and bullæ	2	5	4	11
Hæmatomas	1	6	1	8
Cerebrospinal fluid	4	6	1	11
Total	26	57	38	121

We consider that the finding of red cells containing Heinz bodies in so high a proportion of fluids examined indicates that this is a normal step in the breakdown of red cells which have been shed into the body cavities. In old collections of blood the affected corpuscles are very numerous. For example, in a subdural hæmatoma of 3 weeks standing 70 per cent of the red cells were affected; in a pseudomucinous ovarian cyst 85 per cent, and in a dental cyst of the maxilla 100 per cent of the red cells contained Heinz bodies. In such cases as these the cells show complete loss of hæmoglobin and the inclusions become fixed to the distorted cell membrane. However, in serous cavities from which extravasated red cells are usually absorbed rapidly, such as the pleural and peritoneal spaces, cells containing Heinz bodies are often very scarce.

Although there are a number of reports[1–4] that similar inclusions are formed when red blood cells are incubated *in vitro* under sterile conditions, we have found only one case report in the literature of this century[5], in which Heinz bodies were noted in extravasated red cells *in vivo*. The phenomenon was, however, known to Virchow, and is described in the first volume of his *Archives*[6], but seems to have been since forgotten. Experiments by one of us (R. S. S.) are now in progress to follow the process of Heinz body formation in shed blood, and the results will be published later.

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Antibiotic Substances from Yeast

It was suggested[1] that the micro-organism-inhibiting properties of material from baker's yeast reported by us[2] might lie in a mixture of fatty acids. Although we had found that fatty acids from yeast could inhibit the respiratory metabolism of yeast and tissues[3] we believed that other types of substances might be involved.

The following preparative procedure was finally used. Twenty-five pounds of baker's yeast were extracted with 95 per cent ethanol under reflux for 5 hr. The extract was taken to dryness *in vacuo* and 100 ml. of water were added. After filtration, the aqueous filtrate was acidified to *p*H 2 with 0·1 *N* hydrochloric acid and extracted with ether. The

ether was removed and the residue was dissolved in water and adjusted to *p*H 6. The aqueous solution was extracted with ether and the ether discarded. The aqueous solution was adjusted to *p*H 4 and again extracted with ether. The ether solution was concentrated and placed in one strip on Whatman No. 3 *MM* paper. The ascending chromatogram was developed with water/pyridine/ethyl acetate (400 : 180 : 400). After spraying with ammonium hydroxide, a strip containing material which fluoresced yellow under ultra-violet light could be cut out. The material was eluted with ethanol and the concentrated eluate was chromatographed by the descending technique, using ethanol/water/ammonium hydroxide (80 : 15 : 5) as the solvent. After spraying the paper with ammonium hydroxide, ultra-violet light revealed two strips, *Y*1 with R_F 0·5, and *Y*2 with R_F 0·7. Each was eluted separately with ethanol and the concentrated eluates were separately chromatographed by the ascending technique in water/pyridine/ethyl acetate. Both substances, in yields of about 30 mgm., were colourless, soluble in warm ethanol, and chromatographically pure. They could not be crystallized. They did not give colour reactions on chromatograms with ninhydrin, diazotized sulphanilic acid, Ehrlich's reagent, or cyanogen bromide. Attempts to obtain derivatives with 2,4-dinitrofluorobenzene and picric acid failed.

After hydrolysis with hydrochloric acid, *Y*1, in two-dimensional chromatograms with the solvents phenol saturated with a solution of 6·3 per cent sodium citrate and 3·7 per cent potassium dihydrogen phosphate[4], and butanol/acetic acid/water (4 : 1 : 1)[5], revealed leucine, valine, alanine, glutamic acid and glycine. *Y*2 gave the same amino-acids and, in addition, γ-aminobutyric acid.

Paper electrophoresis in phosphate buffers at *p*H's of 2, 4, 7 and 12 in all cases resulted in migration towards the anode, migration being most rapid at *p*H's 2 and 12. *Y*1 moved faster than *Y*2.

*Y*1 in acetone gave only a low ultra-violet cut-off. *Y*2 had an absorption peak at 255 mμ. γ-Aminobutyric acid gave only end absorption, but after standing in 2·5 per cent concentration in 0·1 per cent hydrochloric acid for a week slight absorption developed at 270 mμ. Infra-red absorption spectra of films on potassium bromide showed both compounds to absorb at approximately 3·0μ, 3·4μ, 5·95μ, 6·1μ (*Y*1), or 6·2μ (*Y*2), and 6·9–7·0μ; *Y*2 also had slight absorption at 8·0μ.

Antibacterial activity of all preliminary fractions as well as of *Y*1 and *Y*2 was determined *in vitro* against *Micrococcus pyogenes*, var. *aureus* by the filter disk method. Some of the fractions were also assayed against the moulds *Aspergillus niger* and *Penicillium glaucum*, and found to be effective. *Y*1, in a concentration of 1 mgm. per disk, produced a 1 cm. zone of complete inhibition of *M. pyogenes* in 24 hr. *Y*2, in a concentration of 0·5 mgm. per disk, gave a similar inhibition. γ-Aminobutyric acid has been shown to be inactive against the organism[6].

The compounds appear to be peptides, and since no free amino-groups have been detected, possibly cyclic peptides. *Y*1, somewhat more electronegative than *Y*2, seems to differ from *Y*2 only in the absence of γ-aminobutyric acid. γ-Aminobutyric acid has been isolated from yeast extract in the free state and has been considered to be a degradative product[5]. Our results suggest but do not prove that the acid may be a constituent of a peptide. Structural considerations obviously will depend upon future analytical studies.

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Recombination Ability of *Escherichia coli* K-12 Protoplasts

Since Repaske's[1] and Lederberg's[2] discoveries, protoplasts of *Escherichia coli* have formed useful material for biosynthetic and genetic studies, for example, in *T*-2 phage multiplication[3,4], in rehabilitation of a deficient mutant[5] and, more recently, in recombination behaviour[6]. During the past two years great advances have been made in our understanding of genetic recombination in *E. coli*, especially through the finding that genetic material is transferred from *F*+ donor into *F*− recipient cells[7–9]. In these situations, genetic recombination between *E. coli* protoplasts was attempted in order to obtain further information on the properties of protoplasts and the process of genetic recombination.

Cells of *E. coli* *K*-12 58–161 *F*+ in the stage of logarithmic growth were protoplasted with 100 μgm./ml. lysozyme and 0·3 mgm./ml. ethylenediamine tetraacetic acid (versene) in a solution of 30 m*M* *tris* buffer and 0·6 *M* sucrose at *p*H 7·8. Protoplasts of *E. coli* were suspended in phosphate buffer (*p*H 7·2) supplemented with 20 μ*M* glucose and 200 μgm./ml. sodium aspartate with and without stabilizer. In the former solution protoplasts were well stabilized (experiment 1) and in the latter they were osmotically shocked and a viscous lysate was obtained to which the same amount of stabilizer was added (experiment 2). The controls were unprotoplasted cells handled identically except for the omission of lysozyme and versene (experiment 3 vs. experiment 1 and experiment 4 vs. experiment 2). These four preparations were mated for 2 hr. at 37° C. with intact *Y*-70 *F* − recipient cells requiring threonine, leucine and thiamine) and then plated on *EMS* medium. Various kinds of stabilizers were tested to ascertain whether they could support the protoplasts and their recombination. It was shown that 0·6 *M* sucrose was the most appropriate stabilizer for this purpose; others, such as disodium hydrogen phosphate and sodium and potassium chlorides, sodium succinate, etc., inhibited recombination in spite of their efficient stabilizing effect. Table 1 shows a typical experiment illustrating the formation of recombinants in phosphate buffer

Table 1. Recombinant Formation from *Y*-70 *F*− Cells mated with 58-161 *F*+ Protoplast and Lysate Preparations

Exp.	*F*−	×	*F*+	No. of recombinants
1	Unprotoplasted		protoplasted	109
2	Unprotoplasted		protoplasted, lysed	42
3	Unprotoplasted		unprotoplasted	179
4	Unprotoplasted		unprotoplasted, lysed	190

Table 2. Differential Centrifugation of Protoplasted and Unprotoplasted Cells

Speed in r.p.m.			1,000	2,000	3,000
Percentage recovery of protoplast			94	5	1
			No. of recombinants*		
$F-$	×	$F+$			
Unprotoplasted		protoplasted	128 ($1{\cdot}4 \times 10^8$)	16 ($3{\cdot}4 \times 10^8$)	0 ($1{\cdot}0 \times 10^8$)
Unprotoplasted		protoplasted, lysed	16 ($1{\cdot}0 \times 10^8$)	16 ($3{\cdot}2 \times 10^8$)	0 ($1{\cdot}0 \times 10^8$)
Unprotoplasted		unprotoplasted	92 ($1{\cdot}1 \times 10^8$)	40 ($3{\cdot}1 \times 10^8$)	12 ($2{\cdot}4 \times 10^8$)

* Figures in parentheses indicate the intact bacterial count per ml. remaining in each fraction.

stabilized with sucrose and supplemented with glucose and aspartate.

This suggested that some but not all of the recombinants were formed at the protoplast level, because the number of recombinants was decreased if the protoplasts were lysed by osmotic shock as in experiment 2. The difference between experiments 1 and 2 was smaller than the initial expectation, but this may be due in part to the slight increase between experiments 3 and 4. In every experiment, of course, intact cells which had not been affected by lysozyme remained in the protoplast and lysate preparations and participated to some extent in the formation of recombinants. However, the number of recombinants which appeared were much in excess of the number expected to arise from residual intact cells at the normal recombination rate ($1{\cdot}4 \times 10^{-8}$ in phosphate buffer). This remains, however, to be studied in detail.

The implications of these experiments were supported by certain differences in behaviour during centrifugation between protoplasted and unprotoplasted cells. Most of the protoplasts formed were easily collected by low-speed centrifugation. About 94 per cent of the protoplasts were deposited in 10 min. at 1,000 r.p.m., and when the supernatant from this first centrifugation was spun again at 2,000 r.p.m., a further 4 per cent of the protoplasts were recovered in the deposit. Each of these was mated directly or after being lysed by dilution with the unprotoplasted $F-$ cells as in the method described earlier.

This experiment showed that the fraction which yields most of the recombinants coincides with that in which most of the protoplasts were recovered.

The reciprocal cross was made in which *Y*-70 $F-$ cells were protoplasted and mated with intact 58-161 $F+$ cells in a similar procedure to that described above.

If the recipient $F-$ cells were protoplasted and lost their capacity for further cell division, recombinant formation would have been inhibited completely. In fact, however (Table 3), a number of recombinants appeared. If all the $F-$ protoplasts were lysed, they presumably could not have acted as recipient cells and yielded recombinants. The 32 recombinants, therefore, must have arisen from mating of the unprotoplasted $F+$ cells with residual $F-$ cells, and their recombination-rates were increased by the liberation of a nutrient material from the products of lysing protoplasts.

Table 3. Recombinant Formation from 58-161 $F+$ Cell mated with *Y*-70 $F-$ Protoplast and Lysate Preparations

Exp.	$F-$	×	$F+$	No. of recombinants
5	Protoplasted		unprotoplasted	42
6	Protoplasted, lysed		unprotoplasted	32
7	Unprotoplasted		unprotoplasted	115
8	Unprotoplasted, lysed		unprotoplasted	120

Table 4. Recombinant Formation from Protoplast and Lysate Preparations

Exp.	$F-$	×	$F+$	No. of recombinants
9	Protoplasted		protoplasted	112
10	Protoplasted		protoplasted, lysed	65
11	Protoplasted, lysed		protoplasted	9
12	Protoplasted, lysed		protoplasted, lysed	4

Further support was obtained from alternative crosses in which both $F+$ and $F-$ protoplasts were mated directly (experiment 9), either $F+$ or $F-$ protoplasts were shocked and mated with $F-$ or $F+$ protoplasts respectively (experiments 10 and 11), and both were shocked and mated together (experiment 12).

These results indicate the one-way transfer of genetic material from $F+$ to $F-$ cells; the appropriate compatibility-type of donor and recipient is required even in the subcellular level. But the question remains whether $F-$ protoplasts which could not divide further by themselves acquired the ability to revert and to form normal colonies after mating with $F+$.

These results with *E. coli* protoplasts illustrate the possibility of a new approach to the study on the mechanism of bacterial recombination and transformation.

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Effects of Flavin Monosulphate and Flavin Adenine Dinucleotide on the Electroencephalogram

Flavin monosulphate (riboflavin-5′-monosulphate) has been found to inhibit D-amino-acid oxidase in competition with flavin adenine dinucleotide[1]. On the other hand, it was supposed that flavin adenine dinucleotide might have some important role in the brain since it reversed the inhibitory action of chlorpromazine on the oxidation of amino-acids by a homogenate of the diencephalon part of the brain[2]. Taking these results into consideration, the effects of flavin monosulphate and flavin adenine dinucleotide on the function of the brain were examined by electroencephalography.

Flavin monosulphate was synthesized by sulphonation of riboflavin dissolved in pyridine using chlorosulphonic acid at 40° C., in dry conditions. The flavin monosulphate was purified by powdered

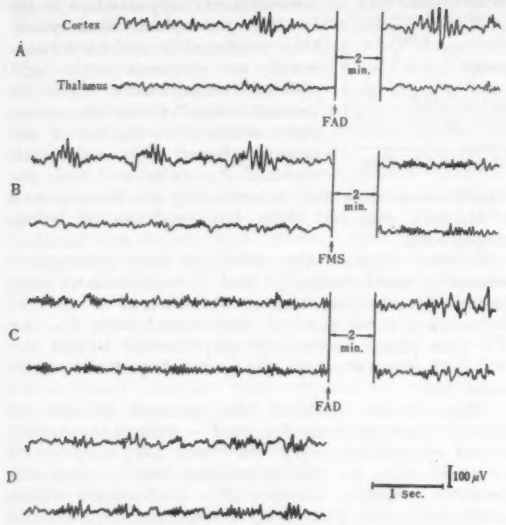

Fig. 1. Effects of the successive injection of flavin adenine dinucleotide and flavin monosulphate on the electroencephalogram. (*A*) Corticogram and depth electroencephalogram from the thalamus before and after the administration of flavin adenine dinucleotide; (*B*) the effect of the administration of flavin monosulphate on the continued electroencephalogram of (*A*); (*C*) the effect of the second administration of flavin adenine dinucleotide on the continued electroencephalogram of (*B*); (*D*) continued electroencephalogram of (*C*)

cellulose chromatography, and finally the calcium salt of flavin monosulphate was obtained as yellow crystals[2]. Flavin adenine dinucleotide was prepared by the method of Yagi *et al.*[4]. Its purity was more than 92 per cent, and other flavins, nucleic acids or metals were not present. Each flavin compound was used as an aqueous solution containing $0{\cdot}25 \times 10^{-6}$ mol./ml.

A guinea pig was narcotized by the intra-abdominal injection of urethane. After craniotomy, two kinds of electrode were placed on the brain; one was on the surface of the cerebral cortex to record the corticogram, and the other was put into the thalamic region to record the depth electroencephalogram. The exact position of the depth electrode was checked by histological examination of the brain after the experiment. The reference electrode was put on the frontal area of the cranium, and the monopolar leads were taken between the reference electrode and the cortex or the thalamic region. For recording, a Grass Model III *D* electroencephalograph was used. When a stable electroencephalogram was obtained, 2 ml. of an aqueous solution of flavin monosulphate or flavin adenine dinucleotide ($1{\cdot}0 \times 10^{-6}$ mol./kgm. of animal) were injected intra-abdominally, and the changes in the electroencephalogram were observed.

After the injection of flavin adenine dinucleotide, the voltage increased in both electroencephalograms. The characteristic change was observed in the corticogram: a slow wave of high voltage in spindle form appeared periodically. On the other hand, after the injection of flavin monosulphate, fast activity of 20–25 c./s. was observed in both electroencephalograms, and the voltage did not increase, but slightly decreased.

The changes in both electroencephalograms after the successive administration of flavin adenine dinucleotide and flavin monosulphate are shown in Fig. 1. By the administration of flavin adenine dinucleotide, the changes mentioned above were observed as shown in Fig. 1 *A*, *B*. 15 min. after the injection, flavin monosulphate was injected, and the remarkable fast activity appeared in both electroencephalograms (Fig. 1 *B*, *C*). Then, 15 min. later, flavin adenine dinucleotide was injected again, and the voltage increased in each electroencephalogram and the frequency decreased (Fig. 1 *C*, *D*). From these results, it seems that flavin adenine dinucleotide and flavin monosulphate have opposite effects on the electroencephalogram to each other.

The effects of free riboflavin and adenosine monophosphate were also examined. Free riboflavin did not cause any change on the electroencephalogram. Adenosine monophosphate had a tendency to increase the voltage, but this change was less than that due to flavin adenine dinucleotide, and the spindle forms were not observed. The effect of calcium ions at a concentration equivalent to that in the aqueous solution of flavin monosulphate calcium salt was also examined, and the result showed no characteristic change.

It is interesting to see that the antagonistic action of two flavin compounds found in the pure enzyme system was also observed in functional phenomena such as the electroencephalogram.

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Activation of an Ascorbic Acid Concentrating Mechanism by Some Corticosteroids *in vitro*

A relation between the actions of ascorbic acid and certain corticosteroids has often been indicated[1]. Since considerable evidence has accumulated that steroid hormones may act by altering the permeability of the cell membrane to a given compound[2] this relationship may be the result of changes in the permeability of certain cellular membranes to ascorbic acid as a result of the action of certain corticosteroid hormones.

To examine this possibility the following experiment was carried out. Six male rats of the Long–Evans strain weighing 250–300 gm. were maintained on a 60 per cent glucose diet[3] for three days. They were then killed, their livers rapidly removed and slices 0·5 mm. thick were prepared. 1 gm. of slices was incubated in 5 ml. of Krebs–Hensleit bicarbonate buffer[4] (*p*H 7·3–7·4) containing 200 mgm. per cent glucose with or without 25 mgm. per cent of the hormone indicated. Complete solubility was not obtained with either hormone, but they were kept

Table 1

Animal	Flask	Hormone	Ascorbic acid diffusing into media per gm. of liver (μgm.)	Decreased diffusion of ascorbic acid per gm. of liver (μgm.)*
1	1A	None	202	25
	1B	Hydrocortisone	177	
2	2A	None	177	34
	2B	Hydrocortisone	143	
3	3A	None	178	25
	3B	Hydrocortisone	153	
4	4A	None	280	74
	4B	Cortisone	206	
	5A	None	214	47
	5B	Cortisone	167	
5	6A	None	260	77
	6B	Cortisone	183	
	7A	None	189	17
	7B	Cortisone	172	
6	8A	None	216	37
	8B	Cortisone	179	
	9A	None	191	41
	9B	Cortisone	150	

* Standard deviation = ± 20

well dispersed while being pipetted. In all cases the liver slices in the flasks of a given number were prepared from the same liver lobe of the animal. At the end of 3 hr. incubation at 37° in an atmosphere of 95 per cent oxygen and 5 per cent carbon dioxide, a 3 ml. sample of the medium was removed and the protein precipitated with 12 ml. of 5 per cent trichloracetic acid. The ascorbic acid was then determined in duplicate for each flask by the method of Roe and Kuether[5]. Tests with standard amounts of ascorbic acid in the presence and absence of cortisone indicated that the hormone had no effect on the ascorbic acid determination. The results are shown in Table 1 and indicate a decreased diffusion of ascorbic acid in the presence of either hormone.

A possible explanation for this phenomenon is the activation of a mechanism for concentrating ascorbic acid by the hormones, either at the cell membrane or at some intracellular site.

Since there is evidence that ascorbic acid is essential to the animal cell for the maintenance of ferrous ions and thus for the continued operation of the citric acid cycle (aconitase) and other reactions dependent on ferrous ions[6], many of the metabolic roles of these corticosteroids may be exerted indirectly by increasing the intracellular concentration of ascorbic acid with the resultant activation of these metabolic reactions based on ferrous ions. A possible permeability barrier to ferrous ions or ascorbic acid or both at the mitochondrial membrane has been postulated[6]. The existence of such a barrier would necessitate an active transport mechanism.

Furthermore, there is evidence that a progressive increase in the production of corticosteroids occurs with increasing ascorbic acid deficiency in guinea pigs[7]. Hence the proposed mechanism may be involved in a homeostasis for the maintenance of optimal intracellular ascorbic acid and the continued operation of fundamental *in situ* cellular reactions dependent on ascorbic acid.

The above mechanism may also play a part in the activation reactions yielding energy associated with adaptation to stress. During stress tissues require greater amounts of ascorbic acid[1] and the increased secretion of corticosteroids that occurs during stress[1] may be a response that is essential to the transfer of this increased ascorbic acid to the intracellular sites where its actions occur.

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Collagen in Human Cementum as shown by Electron Microscopy

Electron microscopy has been used extensively in the study of collagen in skin, tendon and cartilage. Its presence in bone has also been shown by several workers, including Huber and Rouiller[1] and Randall *et al.*[2]. Ascenzi[3], in addition to his own observations, discusses critically the literature on the structure of bone as demonstrated by electron-microscope techniques.

Examination of cementum matrix with the light microscope, using decalcified preparations selectively stained and ground sections of teeth, suggests that it contains collagenous fibres. In view of the close resemblance of cementum to bone as a calcified connective tissue, this investigation was undertaken to ascertain whether collagen fibrils could be demonstrated in human cementum using electron micrography.

Molar teeth extracted from young adults with no clinical disease of the cementum were washed in normal saline and then fixed in formalin. The teeth were bisected in the mesio-distal plane and the interior surface of the inner half polished and etched with $N/100$ hydrochloric acid. The structure of

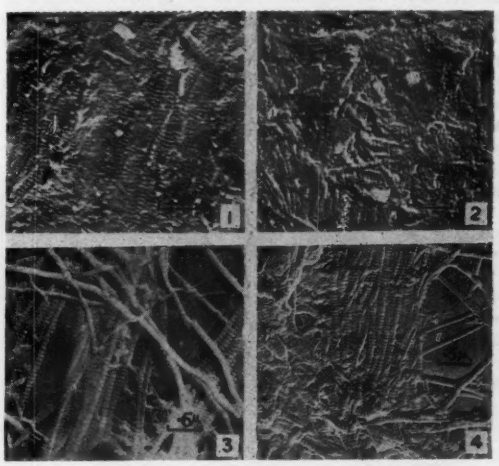

Fig. 1. Bundles of collagen fibrils in cementum, width range 1,000–1,500 A., from first lower molar tooth etched for 30 sec. in $N/100$ hydrochloric acid
Fig. 2. Interlacing collagen fibrils in cementum, width range 300–850 A., from first lower molar tooth, etched for 30 sec. in $N/100$ hydrochloric acid
Fig. 3. Shadowed teased preparation of tendo-calcaneus
Fig. 4. Shadowed carbon replica of tendo-calcaneus

cementum from each of the roots was examined by electron microscopy using gold-palladium pre-shadowed negative carbon replicas taken from the prepared surface.

In all the specimens examined fibrils exhibiting the characteristic 640 A. periodicity of collagen were observed. Broad bundles of fibrils (Fig. 1) having a width in the range 1000–1500 A. were observed. Interlacing fibrils (Fig. 2) were also seen throughout the cementum matrix with a width of 300–850 A.

Fig. 3 shows a shadowed teased preparation and Fig. 4 illustrates a shadowed carbon replica of collagen from the tendo-calcaneus.

The periodicity of the fibrils found in the cementum is 640 A., being the same as that of the collagen from the tendo-calcaneus.

All the material used and illustrated was obtained from women in the age group 20–22 years.

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An Abnormal Hæmoglobin in a Chinese: Hæmoglobin *G*

It has been known for many years that thalassæmia exists among the Chinese. Hæmoglobin *H* was discovered in a Chinese family[1] and has since been seen repeatedly in other Chinese families[2,3]. Thus in Singapore, over a period of fifteen months, 15 unrelated Chinese patients with anæmia were examples of hæmoglobin *H* disease. Another hæmoglobin, *Q*, has so far been observed only once in a Chinese family[4]. Of the other hæmoglobin variants, *E* has occasionally been noticed in Chinese. However, this is a rare finding, and the frequency cannot be compared with that observed in the neighbouring Burmese or Siamese, and certain Malayan, Cambodian and Indonesian communities. Hæmoglobins *S*, *C* and *D*, which are present at some frequency in certain non-Mongoloid populations, have so far never been described in Chinese, neither have been the rarer hæmoglobins *I*, *K*, *L*, *M*, *N*, *O* and *P*.

We have examined several thousand Chinese blood samples, about 5,000 in Singapore (F. V.) and about 500 in London (H. L. in collaboration with R. Bhagvan Singh, Medical Research Institute, Kuala Lumpur, and G. L. Robinson, Seamen's Hospital, Greenwich). Among these, two examples of hæmoglobin *J* were seen[5]. We are now able to record the finding of hæmoglobin *G* in a Chinese woman. The observation was made in the course of a survey of bloods from pregnant women sent for Wassermann tests to the Pathology Department, General Hospital, Singapore. The hæmoglobin of patient 'C3565' resolved on paper electrophoresis at alkaline *p*H into two components, one with the mobility of hæmoglobin *A* (65 per cent) and one with that of hæmoglobin *G* (35 per cent). Hæmoglobin *G* moves under these conditions only slightly more slowly than hæmoglobin *Q*, and slightly faster than hæmoglobins *L*, *P* and *D*, but on chromatography at *p*H 6·0 using ion-exchange resin these hæmoglobins are easily distinguished[4].

There was a slight degree of anæmia (12 gm. hæmoglobin per 100 ml. blood), but this was attributed to pregnancy and iron deficiency. After delivery, and following treatment with iron, the anæmia was corrected and the hæmoglobin-level rose to 14 gm. per 100 ml. blood. There were no morphological abnormalities of the erythrocytes, and fœtal hæmoglobin was not found.

The woman became apprehensive when a special interest was shown in her blood. At first a family study was refused, and soon afterwards the whole family moved to an unknown address in Malaya.

Hæmoglobin *G* was first seen in a West African[6], and its genetic and electrophoretic characteristics have been described by Edington, Lehmann and Schneider[7]. Two further instances of hæmoglobin *G* have been seen in American Negro families by Schneider and Haggard[8], and one in a Nigerian family by N. A. Barnicot, E. M. Shooter and J. P. Garlick (personal communication). A hæmoglobin resembling *G* has been described by Schwartz *et al.*[9] in an Italian family. As this hæmoglobin migrated slightly faster than *G* on electrophoresis at alkaline *p*H, it is possible that this was *Q*. A re-examination by resin chromatography should decide this question.

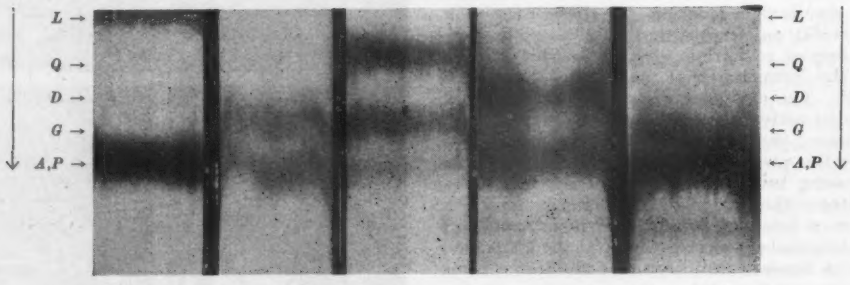

Fig. 1. Separation by resin chromatography on five 'Amberlite *IRC* 50' columns of hæmoglobin *G* from other hæmoglobins showing on paper electrophoresis at *p*H 8·6 only small differences in mobility. The small component in front of the *A* + *P* mixture is a 'pre-*A* band' sometimes seen in samples of hæmoglobin *A* by this technique. For details of technique, see ref. 11. Paper electrophoresis at *p*H 8·6 in order of mobility: *A*, *Q*, *G*, *L* ≡ *P*, *D*. Resin chromatography in order of mobility: *A*, *P* (*P* does not separate from *A*; the mixture forms a broad band), *G*, *D*, *Q*, *L*

Electrophoretic and chromatographic properties depend on the net charges of the globin molecule. Thus hæmoglobins *S* and *D* behave identically on open boundary and paper electrophoresis and in their chromatographic behaviour, but differ in the solubility of the ferrohæmoglobin, and on agar electrophoresis at *p*H 6·0. Hæmoglobins A_2 and *E* have been found to be identical by the current chemical and physical methods of analysis, yet preliminary investigations have demonstrated a difference in their amino-acid sequence (V. M. Ingram, personal communication). The finding of a hæmoglobin variant in this Chinese woman which has the electrophoretic and resin chromatographic properties of hæmoglobin *G* does not necessarily imply its complete identity with the variant seen in West Africans and American Negroes. However, this consideration applies to all identifications of hæmoglobin variants made on the basis of electrophoretic and chromatographic analysis[10].

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Comparative Kinetic Behaviour of Thrombin, Plasmin and Trypsin toward Synthetic Substrates

Thrombin preparations catalyse the hydrolysis of synthetic arginyl[1] and lysyl[2] substrates. While plasmin and trypsin may appear as contaminants in thrombin preparations, we present here kinetic data for the action of these three enzymes toward *p*-toluenesulphonyl-L-arginine methyl ester (I) and the methyl and ethyl esters of lysine which rule out plasmin or trypsin impurities as the origin of the lysyl esterase activity of thrombin.

The kinetic studies were carried out with various thrombin preparations having the following activity towards (I), the substrate adopted for thrombin assays[3]: Seegers citrate-thrombin, 1,000 I units/mgm.; Seegers bio-thrombin, 100 I units/mgm.; Parke, Davis 'Bio-thrombin', 12 I units/mgm. None of these preparations is as pure as that which is attainable (at least 2,000 I units/mgm.) by the procedure of Rasmussen[4]. However, as will be shown, the state of purity does not affect the conclusions.

Experiments on the thrombin – lysine methyl ester reaction were carried out in 0·15 *M* potassium chloride at 25° using 100 I units of thrombin/ml. The hydrolytic reaction was followed by the *p*H-stat method[3] for 30 min. with appropriate corrections for non-enzymatic hydrolysis. The range of concentrations of the lysine methyl ester was limited to 0·001–0·01 *M* since, at higher concentrations, the ionic strength contributed by the dihydrochloride can reduce thrombin activity[3,5,6]. Nevertheless, a significant departure from first-order behaviour in substrate concentration was obtained, thereby permitting a Lineweaver–Burk analysis to be applied to the results.

Various aspects of the kinetic properties of the three enzymes under consideration appear in Table 1; a brief discussion follows.

(*a*) Whereas the plasmin – lysine ethyl ester and trypsin – lysine ethyl ester reactions attain the zero-order region at about 0·03 *M* and 0·02 *M* lysine ethyl ester, respectively, the zero-order region is not reached in the thrombin – lysine methyl ester reaction even at 0·1 *M* lysine methyl ester. Both plasmin and thrombin show zero-order behaviour towards (I) at concentrations of about 0·02 *M*, although the inhibition of plasmin at concentrations of (I) greater than 0·05 *M* (ref. 7) is not observed with thrombin[1,3].

(*b*) The maximum velocity V_m at *p*H 7·0 at 25°, obtained from the Lineweaver–Burk plot, is 0·0036 micromole lysine methyl ester/ml./min. per I unit of thrombin. This may be compared with the value[3] of 0·1 for the thrombin-induced hydrolysis of (I) at *p*H 8·0 at 25°. (By definition[3], 1 unit of thrombin hydrolyses 0·1 micromole of (I)/ml./min. at *p*H 8·0 at 25°.) Although k_3 cannot be computed on an absolute basis because the specific activity of thrombin is unknown, we can compute the ratio of k_3 for I and lysine methyl ester at the same enzyme concentration as the ratio of the values of V_m. This is 28 for thrombin, 1·4 for plasmin and 21 for trypsin.

(*c*) The Lineweaver–Burk plot gives a value of $K_m = 0{\cdot}070$ *M* for thrombin on lysine methyl ester at 25°. This is significantly larger than 0·017 *M* for plasmin on lysine ethyl ester[7] at 37°, although a good comparison of K_m values cannot be made because of the difference in temperature. It is of interest to note that K_m for thrombin, plasmin and trypsin toward (I) seems to be identical.

(*d*) Because of differences in buffer ions, it is not possible to base any definite conclusions on differences in the *p*H optima.

Previous results[3] on the absence of STI inhibition of thrombin and the foregoing kinetic considerations indicate that the lysyl esterase activity in thrombin preparations does not arise from the presence of either plasmin or trypsin. Perhaps the strongest

Table 1. Kinetic Data

Enzyme	Substrate concentration for zero order: Lysyl ester	(I)	Ratio of k_3 for (I) to k_3 for methyl or ethyl lysine ester	K_m: Lysyl ester	(I)	*p*H optimum: Lysyl ester	(I)
Thrombin	not reached ($> 0{\cdot}1$ *M*)	0·01 *M* (ref. 3)	28	0·070 *M*	0·0043 *M* (ref. 1)	7	8 (ref. 3)
Plasmin	0·03 *M* (ref. 7)	0·015–0·05 *M**	1·4 (ref. 7)	0·017 *M* (ref. 7)	0·004 *M* (ref. 7)	6·5 (ref. 7)	9 (ref. 7)
Trypsin	0·017 *M* (ref. 8)	0·006 *M* (ref. 9)	21 (ref. 7)	—	0·004 *M* (ref. 10)	7·5 (ref. 7)	8 (ref. 9)

* Substrate inhibits at concentrations exceeding 0·05 *M* (ref. 7).

evidence that thrombin is itself a lysyl esterase is the finding that, regardless of the state of purification or type of preparation, the ratio of the activity of (I) to lysine methyl ester or ethyl ester remains constant. Thus, a 100-fold increase in purity resulted in only minor changes in the magnitude and shape of the *p*H – lysine methyl ester activity curve. The same holds true for the *p*H–(I) activity curves for these preparations[9].

In conclusion, thrombin has lysine esterase activity but, as discussed elsewhere[11], the lysine esterase site probably differs from the hydrolytic site for (I) and for fibrinogen. Further studies on thrombin are in progress.

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Vanadium Inhibition of Phospholipid Synthesis and Sulphydryl Activity in Rat Liver

The effect of various transition elements on lipid and sterol metabolism has received attention in recent years[1]. For example, both vanadium and members of the rare-earth group are capable of producing a fatty infiltration of the liver. Furthermore, vanadium can cause a marked reduction in cholesterol and phospholipids[1,2]. In this connexion, work has been directed towards investigating a possible prophylactic action of vanadium against atherosclerosis[2]; it has been suggested that disruption of the endogenous balance of the transition elements in the liver could underlie the pathogenesis of this disease[1].

The increased *in vitro* oxidation of the fatty acid moiety of phospholipids occurring in the presence of vanadium[3] may account for the decreased phospholipid levels in animals fed vanadium, but it has not ruled out the possibility of an independent effect of vanadium in retarding liver phosphatide synthesis. This possibility was tested *in vivo* by measuring the incorporation of phosphorus-32 into liver phospholipids of rats shortly after injection of labelled phosphate.

Since Mountain *et al.*[4] have previously reported interference of sulphur amino-acid metabolism in vanadium toxicity, an additional group of animals was used to ascertain the effect of vanadium on the incorporation of L-methionine-^{35}S into liver protein, and on the amount of sulphydryl soluble in trichloracetic acids in the liver.

The Sprague–Dawley rats weighing approximately 170 gm. used in these studies were maintained on a 5 per cent casein diet[5] for 11 days. Animals were injected intraperitoneally with a vanadyl sulphate solution (0·75 mgm. vanadium in 0·5 ml. saline/100 gm. body-weight)[1] or saline (0·5 ml./100 gm. body-weight). The isotope (10 μc. of $NaH_2{}^{32}PO_4$ or 15 μc. of L-methionine-^{35}S) was administered by the same route immediately after the animals received the vanadium or saline. The rats were killed 3 hr. later. The livers, after being rapidly excised and weighed, were analysed in a manner similar to that described previously for phospholipid[6] and sulphur[6] turn-over. The relative specific activity of the phospholipids and the specific activity of total protein sulphur were calculated from the chemical and radioactive measurements.

Table 1. Effect of Vanadium on Phospholipid Synthesis and Sulphur Turn-over in Liver of Rats

	Saline controls	Treated with vanadium
No. of rats	6	6
Phospholipid relative specific activity*	0·101 ± 0·015	0·075 ± 0·018§
Protein sulphur specific activity†	12·8 ± 1·8	16·8 ± 1·0§
Sulphydryl compounds, mgm.‡ (TCA soluble)	0·37 ± 0·05	0·26 ± 0·03§

* Relative specific activity = $\frac{\text{specific activity of phospholipid-phosphorus}}{\text{specific activity of inorganic phosphorus}}$

where the specific activity of phosphorus is defined as $\frac{\text{(counts/min. phosphorus-32)}}{\text{(mgm. phosphorus) (counts/min. of dose injected} \times 100)}$

† Sulphur specific activity = $\frac{\text{(counts/min. sulphur-35) dekagm. of body-weight)}}{\text{(mgm. sulphur) (counts/min. of dose injected)}}$

‡ Reported as mgm. of cystine per gm. of wet weight.

§ $P < 0{\cdot}05$ calculated from the t test of significance. The figures preceded by the ± are the standard deviation.

The results are reported in Table 1. They suggest that the decreased phospholipid values observed in animals fed vanadium[3] result from inhibition of phospholipid synthesis and are probably augmented by oxidative degradation[3]. An alteration in sulphur metabolism is also apparent from the reduction of the sulphydryl content of the liver soluble in acid and from the increased turn over of protein sulphur in the animals which received the vanadium.

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Relative Stability of Adrenaline, Noradrenaline and 5-Hydroxytryptamine subjected to Various Simple Treatments

WHEN the distribution of active materials in vertebrate tissue is being studied, it is necessary to free tissue extracts from substances which interfere with the bioassay of 5-hydroxytryptamine. Garven[1] has described a method for the destruction of polyphenols by the polyphenol oxidase present in mushroom juice. The juice contains both polyphenol and monophenol oxidase, and her method therefore makes use of the faster inactivation of adrenaline and noradrenaline by polyphenol oxidase than of 5-hydroxytryptamine by monophenol oxidase. The present method depends on the differential stability of 5-hydroxytryptamine, adrenaline and noradrenaline in alkaline solution.

tions 50–200 times those which were found to abolish the response of the tissue to the stated amounts of 5-hydroxytryptamine are completely inactivated by standing for 30–60 min. at *p*H 11 without loss of 5-hydroxytryptamine itself. Heating to 98° C. for 5 min. at *p*H 7·8 is equally effective. Heating for 1 min. at 98° C. and *p*H 9·6 leads to a small loss, and at *p*H 11 to a considerable loss of 5-hydroxytryptamine activity. This last result differs from that reported by Pernow[2].

Human serum to which adrenaline, noradrenaline and 5-hydroxytryptamine had been added was extracted by addition of four volumes of acetone[4]. When sodium hydroxide was added to the extracts to give a *p*H of 10·5–11·0 for 30–60 min., adrenaline and noradrenaline were destroyed whereas 5-hydroxytryptamine was unaffected. Three such experiments

Table 1. EFFECT OF TEMPERATURE AND *p*H UPON RESPONSE OF RAT STOMACH TO SOLUTIONS CONTAINING 5-HYDROXYTRYPTAMINE (5-HT), ADRENALINE (Ad) AND NORADRENALINE (nor-Ad)

All recoveries as percentage (mean ± standard error) of response to untreated solutions containing 10 or 20 mμgm./ml. 5-hydroxytryptamine base (5-hydroxytryptamine creatinine sulphate, May and Baker)

Figures in brackets show number of separate experiments performed

*p*H	Duration of treatment (min.)		Percentage of response to control sol. (5-HT only, *p*H 6·8–7·8, untreated)			
	Room temp.	98° C.	5-HT	5-HT + Ad 1 μgm./ml.	5-HT + nor-Ad 1 μgm./ml.	5-HT + Ad 1 μgm./ml. + nor-Ad 1 μgm./ml.
6·8–7·8		1	99·3 ± 0·75 (4)	0 (2)	60·5 ± 10·5 (2)	—
		5	97·0 ± 6·00 (2)	—	—	97·0 ± 8·00 (2)
	120–240		100·0 ± 3·30 (15)	Relaxation (6)	Relaxation (6)	Relaxation (2)
9·6		1	97·3 ± 1·50 (4)	93·0 ± 1·00 (2)	91·0 ± 3·00 (2)	—
		2	86·0 (1)	—	—	78·0 (1)
	120		—	—	0 (1)	—
10·8–11·2		1	67·3 ± 2·92 (4)	55·0 ± 5·00 (2)	76·5 ± 7·50 (2)	—
	5		96·5 ± 4·50 (4)	0 (5)	—	—
	30		98·0 ± 2·00 (2)	114·0 ± 2·00 (2)	—	—
	60		96·9 ± 3·78 (7)	101·8 ± 3·11 (6)	—	103·0 (1)
	120		88·2 ± 2·97 (5)	92·5 ± 12·50 (2)	92·3 ± 3·80 (4)	80·0 (1)

Solutions containing 10 or 20 mμgm./ml. 5-hydroxytryptamine were prepared, ± 1 μgm./ml. adrenaline and ± 1 μgm./ml. noradrenaline, in Tyrode's solution bubbled for 30 min. previously with a gas mixture of 5 per cent carbon dioxide, 95 per cent oxygen. The volume (0·2–0·4 ml.) of analytical grade sodium hydroxide to give the required *p*H was added to 25-ml. aliquots of solutions in 50-ml. stoppered flasks or test-tubes. The solutions were well mixed by shaking and either left to stand on the bench at room temperature or heated in a water-bath at 98° C. and then cooled in iced water. Analytical grade hydrochloric acid was added to restore the *p*H to neutral, the solutions were well shaken and remained on the bench at room temperature until they were assayed (about 2 hr. later). There is no significant loss of activity during this time ($P > 0{\cdot}2$). The *p*H of the solutions was checked initially with Johnsons's narrow range indicator papers and in critical experiments by an E.M.I. direct-reading *p*H meter.

5-Hydroxytryptamine was assayed upon the rat stomach preparation[3] in Tyrode's solution at 38° C. Doses were given according to a 'Latin square' design. In all experiments the test solutions were compared with untreated solutions of 5-hydroxytryptamine to which Tyrode's saline had been added in volumes equal to those of sodium hydroxide and hydrochloric acid. All recoveries are expressed as percentage of response to untreated solutions containing 5-hydroxytryptamine only.

Table 1 summarizes the results of fifteen experiments. Adrenaline and noradrenaline in concentrations gave recoveries of 5-hydroxytryptamine between 92 and 100 per cent of the control value (96·2 ± 1·7).

Thus both adrenaline and noradrenaline in a concentration of 50–200 times that of 5-hydroxytryptamine—a ratio which occurs in certain parts of the brain of vertebrates[5,6]—are selectively destroyed by treatments which have little or no effect on the concentration of 5-hydroxytryptamine.

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Application of Direct Photographic Photometry to Preparative Electrophoresis

THE supporting medium of most preparative methods of electrophoresis includes a solidified gel or porous solid in order to reduce thermal convection[1]. A buffer stabilized in the form of a clear solution, without a solid support, would have the advantages of avoiding adsorption effects between the migrating

molecule and the solid, and would make it possible to follow the migrating substances by direct photometric procedures[1]. A method of electrophoresis has been described which uses, as a medium, a thin film of buffer solution[2]. Thermal convection can be effectively controlled by dissolving in the buffer a sufficient quantity of gelling agent to impart a trace of rigidity or thixotropy. Not enough is added to cause a loss of fluid characteristics (that is, to run freely when tilted) or a loss of transparency. The amount of protein that can be separated can be increased for preparative purposes by increasing the thickness of the buffer from that of a thin film to a solution 1 cm. or more. Direct photographic photometry applied to the separation and isolation of serum proteins by this method was accomplished by the following procedure.

A cell bottom 6·5 in. × 13 in. was constructed of two 6·5 in. squares of Corning No. 7910 glass. These were glued together with glass strips to form a rectangular container. 'Difco' agar, one of various gelling agents which can stabilize in trace amounts, was added to a 0·02 *M* veronal buffer, *p*H 8·6, to a concentration of 0·16 gm. per cent. It was dissolved by boiling, and 500 ml. of the solution was poured into the cell while still warm. Cellulose sponges were used for electrical contact with electrode vessels, each filled with the same solution up to the same level as in the cell. The solution was permitted to stand for a half-hour, and a potential gradient of 6·1 V./cm. was then applied. 1 hr. later the serum was introduced by attaching a 14 cm. × 0·6 cm. piece of Whatman No. 17 paper with thread to a plastic frame, wetting the paper with serum, and then inserting the frame down into the buffer solution along vertical grooves which had been prepared inside the glass sides. Serum can also be applied by solidifying a block with agar.

The proteins were followed at various times during the course of their migration by inserting photographic plates into a space left vacant under the cell. These were exposed to light of 283 mμ wave-length for 11 min. A Beckman *D.U.* monochromator with a hydrogen lamp was used as light source. The monochromatic light beam was extended horizontally for 18 ft., then deflected by means of an aluminium mirror down through the electrophoretic cell. The photographic plates were developed, and the positions of the protein components were determined by means

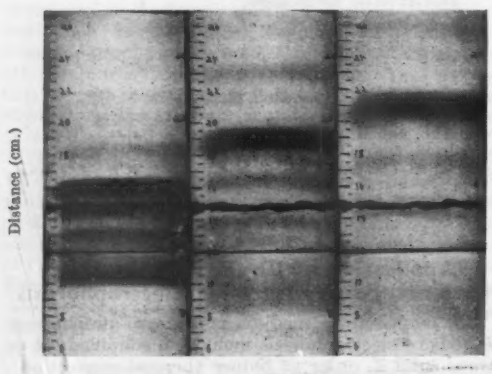

Fig. 1. Printed photographic plates obtained at 2·5, 4·5 and 5·5 hr. of migration. The line at 12 cm. was due to the frame used to apply serum, and the irregular line at 14·7 cm. was caused by the glue connecting the two silica plates of the cell bottom

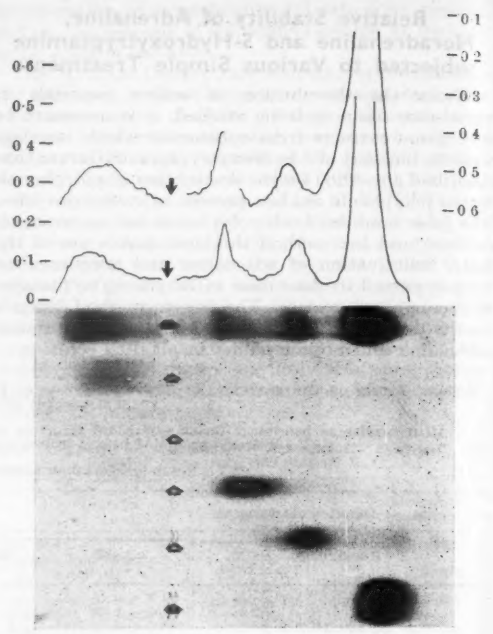

Fig. 2. Film electrophoresis of the original serum and components included in the following sections of the preparative cell: 6–10, 10–13, 13–16, 16–19 and 19–22 cm. The top curve gives the absorbancy along the last photographic plate of Fig. 1, right-hand scale, while the lower curve represents the stained pattern below it, left-hand scale. Arrows indicate position of application

of a centimetre scale drawn on the bottom of the cell (Fig. 1). The current was then disconnected, and the protein fractions were separated by inserting aluminium sheet dividers down into the solution at appropriate positions along the centimetre scale. The dividers were connected by tape along the outside of the cell, which was placed in a freezer. The frozen sections were removed individually, thawed, and the agar removed by centrifugation. After concentration to approximately the original volume, each fraction was subjected to electrophoresis, along with the original serum, by the fluid film technique. The results, after staining with amido black, are presented in Fig. 2. Densitometer curves were obtained from the stained electropherogram and from the third photographic plate of Fig. 1.

Although the volume of serum applied above was only slightly more than 1 ml., considerably larger amounts can be used. The ability to follow the course of the proteins during electrophoresis and to isolate the individual components by the simple method described, without continuous sectioning or analysis along the migration path, may prove of value for various purposes. The use of ultra-violet photographic photometry for quantitative measurements is being investigated.

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Co-ordination in Thorium-IV Acetylacetonate

ALTHOUGH the number of atomic species with co-ordination number eight is not large, little is known about the structure of eight-co-ordinated complexes. Up to now only two of five possible polyhedra have been established for this co-ordination, namely, a trigonal dodecahedron and an Archimedean square antiprism[1], while cube, triangular face-centred and rectangular face-centred trigonal prisms have not yet been observed. These polyhedra were proposed on the basis of quantum-mechanical calculations on the form of hybrid bond orbitals.

In general, it is possible to predict the co-ordination polyhedron for a given complex if the valency electron orbitals are known and if the co-ordination is not high. This is not the case with heavy atoms, particularly with actinides, where there are many electrons distributed over s, p, d or f orbitals, so that we cannot recognize which is the most favourable configuration for covalent bonding[2]. The direct experimental verification, for example, the X-ray analysis of the crystal structure of heavy metal complexes, is therefore of considerable interest in inorganic stereochemistry.

Metal acetylacetonates of formula $M^{IV}(C_5H_7O_2)_4$, where M^{IV} is zirconium, hafnium, thorium, uranium, polonium or cerium with the co-ordination number eight, are a very promising subject for such analysis. We started our work with the thorium compound[3].

The crystals of thorium acetylacetonate are monoclinic holohedral, the space group being $C_{2h}^5 - P2_1/c$ with four molecules in the unit cell which has the dimensions: $a = 11{\cdot}67$ A.; $b = 12{\cdot}69$ A.; $c = 16{\cdot}95$ A.; $\beta = 112° 15'$.

Multiple-film Weissenberg photographs, taken with copper $K\alpha$ radiation, were used to obtain intensity data for $h0l$ and $0kl$ reflexions. The relative intensities were determined from the optical densities measured at the centre of each spot by means of a microdensitometer. In order to facilitate the absorption correction the specimen was made cylindrical by grinding. The thorium atom parameters were obtained from [010] and [100] Patterson projections. The signs of the structure factors $F(h0l)$ and $F(0kl)$ were determined using only thorium atom contributions and then the corresponding projections of electron density distribution were computed by the Fourier synthesis. Besides thorium atom maxima at $x = 0{\cdot}191$; $y = 0{\cdot}146$; $z = 0{\cdot}200$, a large number of peaks appeared in both projections. A careful examination of the [010] projection revealed a six-membered ring containing the thorium atom peak as well as both methyl-group peaks. It belonged to the acetylacetonate ring which was nearly parallel to the plane of projection. Next, a trial procedure was undertaken which consisted mainly of casting the shadow of wire and sphere models on both electron density maps by means of a distant source of parallel light. At first the square antiprism as a co-ordination polyhedron was assumed, since it involved only three considerably different geometrical isomers (Fig. 1) with the symmetry D_4, D_2 and C_2, respectively. This first step was fruitful and all peaks on both projections were explained by the structure based on the configuration (b) in Fig. 1.

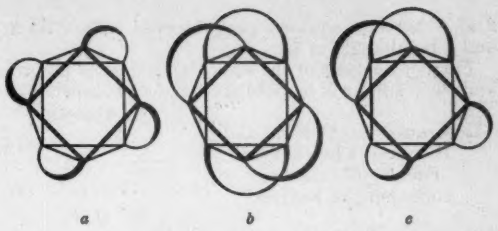

Fig. 1. Geometrical isomers of an eight co-ordinated acetylacetone complex in the Archimedean square antiprism form

The model of the thorium acetylacetonate molecule related to both projections is shown in Fig. 2. Besides the diffraction effect caused by the heavy thorium atom, the maxima in the projections overlapped in many places, which interfered with an exact evaluation of atomic positions. The structure is now being refined so that the present results are only preliminary.

The bond-length Th—O is 2·41 A., and the OThO bond angle is 70°. The O . . . O distance within an acetylacetonate ring amounts to 2·74 A. and the distances between two adjacent rings are 3·05 A. and 3·10 A., along the edge of square and triangular faces, respectively. It follows, therefore, that the actual co-ordination polyhedron is a square antiprism with a slight characteristic distortion. An idea of the amount of distortion can be obtained if we take the Th—O bond length for granted, when the ideal square antiprism requires an edge of 2·93 A., a distance of

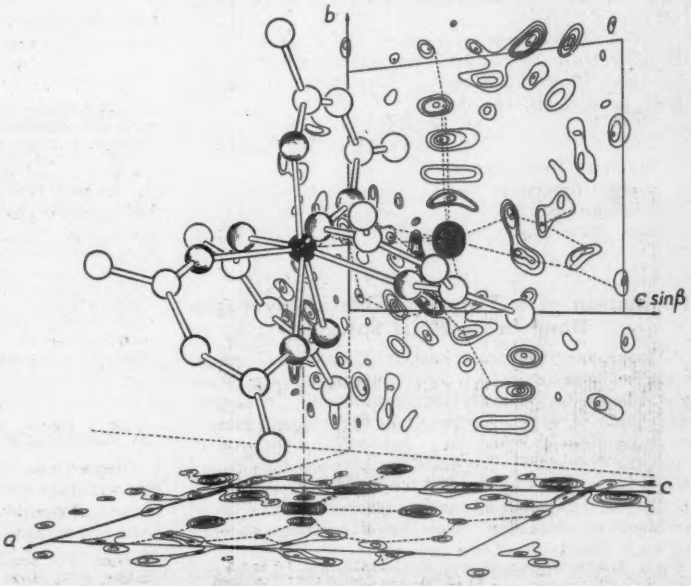

Fig. 2. Perspective view of the model of thorium-IV acetylacetonate molecule as obtained from ($h0l$) and ($0kl$) electron-density maps

2·47 A. between square faces (observed value 2·53 A.) and a bond angle of 75°.

Further analysis of the structure is now in progress and the results will be published in detail elsewhere.

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Absorbents for Aldehydes and Olefins

The usual forms of absorbents for aldehydes, such as ammonia and bisulphite solutions, cannot readily be used in vacuum systems because they are liquid and volatile. A very convenient absorbent may be made by suspending on 25–52 mesh powdered firebrick ('Fossalsil') 25 per cent by weight of a mull of sodium bisulphite in ethylene glycol. We have repeatedly used this powder packed in 10 cm. of a 15 mm. internal diameter tube to absorb the butyraldehyde remaining in a mixture after a photolysis. Subsequent analysis of the reaction products indicates that less than 0·3 μmole out of the initial 500 μmoles remains unabsorbed after the vapour has been passed three times through the packed tube. Acetone is not similarly absorbed.

An excellent absorbent for olefins may similarly be made from a mixture of 9 gm. mercuric acetate, 3 gm. mercuric nitrate and 20 gm. ethylene glycol on 100 gm. of firebrick.

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Formation of a Transition Metal–Hydrogen Bond in Aqueous Solution

There are several known transitional metal complex systems which are concerned with either the absorption or evolution of molecular hydrogen, and some of them, for example the copper acetate in quinoline system, can function as hydrogen-transfer systems[1–3]. It has been suggested by many workers in the past that complexes containing hydrogen bonded to a transitional metal are involved in these systems, but direct proof for the existence of such bonds has been lacking.

A sufficient number of complex compounds containing metal-hydrogen bonds has now been studied by high-resolution nuclear magnetic resonance methods to permit the specific characterization by this technique of a proton bound to a transitional metal. Thus the compounds $(C_5H_5)_2ReH$, $(C_5H_5)_2ReH_2^+$ (ref. 4), $HCo(CO)_4$ (ref. 5), $H_2Fe(CO)_4$ (ref. 6), $HMn(CO)_4$ (ref. 7), $HM(CO)_3(C_5H_5)$ [M = Cr, Mo, W] (ref. 8), $HPtCl(PR_3)_2$ (ref. 9), and $(C_5H_5)_2MH_2$ [M = Mo, W] (ref. 7) have all been shown to have proton resonances shifted to 450–800 cycles/sec. (at 40 Mc./s.) relative to water, on the high field side.

During the course of studies of such compounds and related systems we have examined the cobaltous cyanide–potassium cyanide system, which has been rather carefully studied by Winfield and others[1,2,10]. In aqueous solutions a proton resonance at a position characteristic for a proton bound to the metal atom has been detected, at 698 ± 2 cycles/sec. (at 40 Mc./s.) relative to water. The resonance is not observed at cyanide/cobalt ratios less than 3·5, and it is not affected by excess cyanide up to a cyanide/cobalt ratio of 8·0. The presence of an atmosphere of hydrogen above the solution is not necessary for the appearance of this resonance line, so that the proton bound to the metal is clearly derived from water. The rest of the water molecule, either as free OH radicals or as oxygen, presumably oxidizes the aquo cobaltous cyanide complex. The proton resonance disappears on admission of oxygen and other oxidizing agents to the solution. While there is, as yet, no specific information concerning the nature of the hydrogenated species, it seems reasonable to postulate that it is the $[HCo(CN)_4]^=$ ion. The large chemical shift of the proton resonance shows that the proton in such a species is exchanging with water in the aqueous alkaline solution only very slowly, and the average chemical life-time of the proton on the metal atom must be greater than about 10^{-4} sec.

These studies will be more fully described elsewhere.

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A Radiocarbon Profile in the Tasman Sea

During recent hydrological investigations in the eastern Tasman Sea by the New Zealand Oceanographic Institute a series of sea-water samples was collected for carbon-14 analysis as mentioned recently by Rafter and Fergusson[1].

The sampling position (New Zealand Oceanographic Institute Station *A*344) was in approximately latitude 37° 25′ S.; longitude 170° 35′ E. over

Table 1

Depth (metres)	Volume carbon dioxide (litres)	^{14}C activity w.r.t. *Pinus* (per cent)	'Age' (before present) (years)
0	12·4	+1·01 ±0·50	0
100	15·0	−0·2 ±0·45	100±50
280	18·0	−6·4 ±0·35	590±50
830	17·4	−8·0 ±0·38	720±50
1,400	21·0	−16·1 ±0·40	1,480±60

the head of the New Caledonia Trough in a depth of some 1,900 m. The station was worked on February 14, 1957, under the direction of Dr. R. W. Burling from R.N.Z.F.A. *Tui*. 40 gallon samples were obtained, using an open-ended sampler with a capacity of 20 gallons. Sample depths, the carbon-14 activity of samples with respect to that of the softwood *Pinus radiata*, the New Zealand contemporary standard, together with the derived apparent ages (namely, the time elapsed since air-sea equilibrium obtained), are given in Table 1. These analyses were made in the Nuclear Sciences Division of the Department of Scientific and Industrial Research, Lower Hutt, under the direction of Mr. T. A. Rafter.

The hydrological situation is described in terms of the results of a standard reversing bottle cast made at this station (Table 2). Water analyses and reduction of the results were by me.

Table 2

Depth (metres)	Temperature (°C.)	Salinity (‰)	Dissolved oxygen (ml./l.)
0	21·15	35·45	4·82
10	21·14	35·46	5·10
20	21·11	35·46	5·54
30	21·00	35·45	6·45
50	19·86	35·44	7·18
75	16·94	35·45	5·77
100	16·10	35·46	5·08
150	14·90	35·46	3·82
200	14·09	35·43	2·50
300	12·61	35·26	1·00
400	11·10	35·11	0·87
500	9·76	34·99	1·01
600	8·70	34·90	1·29
800	6·88	34·76	1·88
1,000	5·47	34·66	2·51
1,200	4·39	34·64	3·18
1,500	3·36	34·71	3·80
1,800	2·71	34·79	4·29

The observations have been plotted in the form of temperature, dissolved oxygen and 'age' as functions of salinity (Fig. 1). By projecting the tangents on the temperature–salinity curve, the three primary water types giving rise to the observed characteristics (assuming predominant vertical mixing) have been derived. *A* is the upper subtropical water at a depth of about 160 m., water above this depth being subject in large measure to external (climatic) influence. *B* is the core of the Antarctic intermediate water at about 1,100 m. (originating in surface layers near the Antarctic Convergence) and *C* the deep water (probably entering the Pacific from the Atlantic via the India Ocean) which here extends to the bottom. A discussion of the history of these water masses forms the basis of a consideration (in preparation) of the full hydrological results of the cruise from which the results given here were derived. Particularly noteworthy are the absence of circumpolar bottom water (probably due to isolation by bottom topography) and the significant increase in salinity of the deep water over that found by earlier investigations (for example, *Dana* station 3650 (1920)) in this area. This

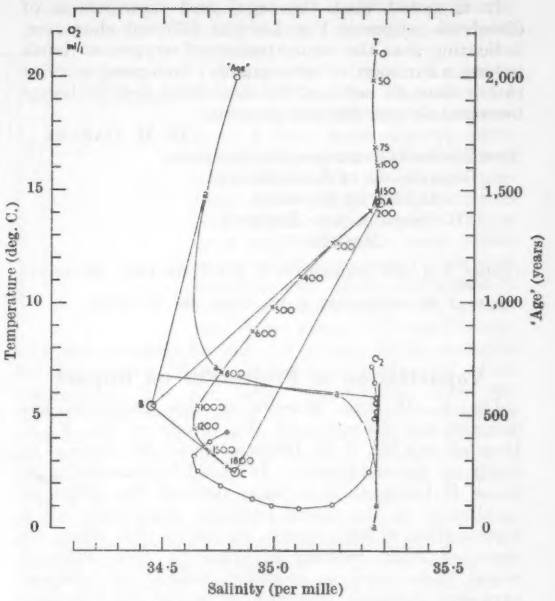

Fig. 1. For station *A*344 the temperature (T, ×———×), dissolved oxygen content (O_2, O———O) and carbon-14 'age' (*a*———*a*) are plotted as functions of salinity in the water column over the New Caledonia Trough in the eastern Tasman Sea on February 14, 1957. *ABC* is the triangle of mixing derived from the temperature–salinity correlation, beside which is entered a depth scale (small figures) in metres

increase has been traced over a large area of the south-west Pacific.

If the carbon-14 activity can be regarded as a conservative water property, the mixing diagram constructed from the 'age'-salinity correlation should indicate a similar water-mass structure to that implied by the temperature–salinity curve. From a graphical construction based on the observations in Fig. 1 it is found that the measured 'ages' are consistent with the temperature–salinity diagram if 'age' values for the primary masses are as follows: *A*, 600 years, *B*, 600 years and *C*, 2,000 years. The prolonged isolation of the deep water (*C*) is notable and may be compared with the value of 2,540 ± 100 years reported by Brodie and Burling[2] from a depth of 2,643 m. in the Southern Ocean south of New Zealand in December 1956. It is likely that the point *C* in Fig. 1 lies above the core properties of deep water because of the relatively shallow depth.

This elementary approach towards accounting for the variation in the carbon-14 activity of the water column in terms of vertical mixing between the main oceanic water masses will need closer examination. Also, because of the time taken to obtain a sufficient volume of water for each determination, only a few points in the vertical profile are sampled. It will be important to see that future samples are adequately located with respect to the turning points in the salinity–depth relationship.

It will be interesting to follow the variation of the 'primary' values derived in the above manner at various points along the cores of the principal water masses, particularly the Antarctic intermediate layer. With the magnitude of lateral mixing defined from temperature–salinity data, it should be possible to make a direct estimate of the velocities involved.

It is noted that the 'age' and distribution of dissolved oxygen in Fig. 1 are of different character, indicating that the concentration of oxygen at depth is here a function of (presumably) biological activity rather than an index of the time since free exchange between air and sea was possible.

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Vaporization of Projectiles on Impact

Dr. K. H. Lih, director of this Institute, has directed my attention to the article of Dr. F. P. Bowden and Mr. J. H. Brunton about the damage to solids by liquid impact[1]. It would be interesting to know if these authors have noticed the effect of 'explosion' of the water particles when they hit a hard surface at high speeds, similar to that which we observed when making experiments with different metal liners used in so-called 'hollow' or 'shaped' explosive charges; although, of course, the velocities of the liner particles far exceed those which Bowden and Brunton used for propelling their water drops. In the *Scientific Monthly* of February 1951, p. 79, it was remarked that: "Ballistic experiments have shown that particles, travelling at velocities about 4,250 ft./sec., *explode into vapour* on striking the target".

That this is actually so is proved by Fig. 1, which shows the surface of the second steel block (diameter 4 in., height 4 in.) hit by the jet particles which had already passed through the first block of the same dimensions; the vapour of the exploding metal particles condensed on the cold surface and left a white spot around the point of impact. That such spots are not produced by droplets of molten metal forced between the two blocks, but by the condensed vapour, was proved by the following experiment: a brass liner was fired into a steel block provided with several apertures running perpendicular to the jet passage; when the block was cut lengthwise it was discovered that at some places in these holes zinc vapour had condensed, which could only happen if at least part of the metal was in gaseous state.

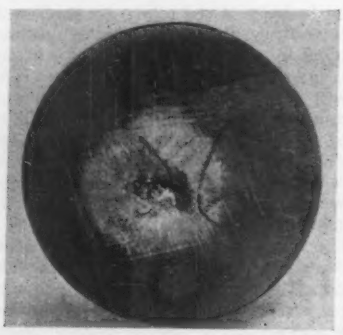

Fig. 1. Condensed metal vapours of exploding jet particles imprinted on the surface of the second steel block

Fig. 2. Cross-sections of 'slugs' showing the copper cores

Fig. 2 explains the formation of the 'slug': small additional copper cones were fixed into the steel liners; the charges were fired horizontally into a sand box, and the metal fragments recovered. The 'slugs' were found to be solid steel bodies with a copper core, which proves that, contrary to some theories, the liners are not turned 'inside out'—at any event at the top—but simply compressed by the force of detonation and torn from the rest of the liners, the lower parts giving most of the high-velocity fragments which penetrate deeply.

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[1] *Nature*, **181**, 873 (1958).

Effect of Solar Flares on Earth Satellite 1957β

Fig. 1 appears to demonstrate a correlation between the fluctuations in the rate of decrease of the period of satellite 1957β and contemporaneous variations in total intensity of solar flares.

The upper part of Fig. 1 is a block diagram with ordinates computed from the daily sum, over all observed flares, of their (area × duration). To aid comparison, I have plotted only the arithmetic mean of this sum over periods between successive satellite observations. The scale is shown by the arrow, which denotes the ordinate equivalent to 1,000 sq. deg. min./day (for example, 1 hr.-long class 3 flare per day). The data have been compiled from the Fraunhofer and Meudon daily Sun disks, and I am indebted to Mr. J. H. Reid, of the Royal Observatory, Edinburgh, for this information. For simplicity only flares of class 2 and above were included in the calculations.

The orbital data of the lower part of the figure were prepared from a graph of various observations published by the Royal Aircraft Establishment, Farnborough, for which I am indebted to Mr. D. G. King-Hele. The ordinates denote the difference between the observed rate of decrease of period and a theoretical figure for this quantity (relating to the same stage of the life-time). Because the theoretical rate varies monotonically with time, its introduction in no way obscures the fluctuations of the observed rate, but rather serves to facilitate their presentation. Similarly, the derivation of the theoretical figures used is immaterial in the context.

The similarity of the two sets of fluctuations, even in some small details, is suggestive. If it is conceded that it may not be purely coincidental, it would be

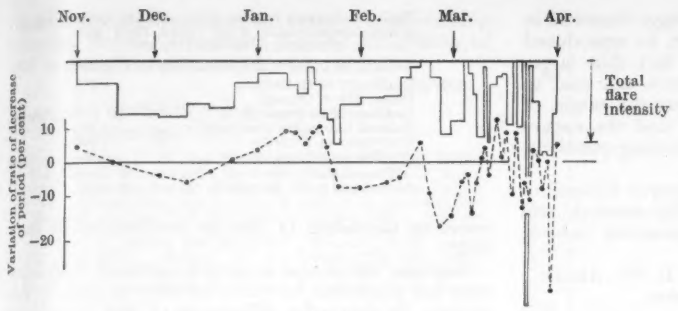

Fig. 1

valuable to establish a possible mechanism for the dependence.

However, it is to be noted that the sense of the relation is such that flares would have to be associated with a temporary decrease in air density, and/or temperature, within the lower ionosphere. (The satellite perigee fell from 140 to 100 miles height during the time shown.) To account for the diagram, this reduction would seemingly have to happen on a world-wide scale, as the perigee ranged during the life-time from middle to equatorial latitudes, and through daylight and night zones.

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Reversals of the Earth's Magnetic Field

Among the many surprising results of studies of the natural remanent magnetization of rocks[1], one of the most curious has been the conclusion that the Earth's magnetic field has undergone changes of polarity; that, in fact, reversals of the main field have been a persistent feature of its behaviour. Normal and reversed fields could equally well exist, according to the dynamo theory of the Earth's magnetism[2], but it is not known whether a means of transfer from one field to the other exists.

Several years ago, E. C. Bullard[3] examined the behaviour of a simple homopolar disk dynamo in some detail, and suggested that systems of such dynamos, together with electrical loads, might provide useful analogies to homogeneous fluid dynamos. He found an interesting oscillatory behaviour of the current and angular velocity for a single dynamo, but there was no phenomenon of reversal. Recently, T. Rikitake[4] set out the equations for two disk dynamos coupled to one another, and from a numerical integration concluded that it was possible for the currents in their coils to change sign; in other words, the fields produced could show reversals, at least initially.

Using the digital computer EDSAC II at the University of Cambridge Mathematical Laboratory, I have been able to carry out much more extended numerical integrations of these equations for a range of parameters and initial conditions. These have exhibited some very subtle types of behaviour, and show that reversals can occur under a wide range of conditions. The system has two states of equilibrium, with the currents for one the reverse of the currents for the other. The equilibrium is stable for small oscillations, but for larger departures from the steady-state values many of the solutions oscillate first about one point of equilibrium and then about the other. Fig. 1 shows a striking example of this behaviour; the current in the coil of one dynamo only is given. It oscillates in one manner for some time, reverses for a single oscillation, and reverts to the original manner; then later a whole series of the reverse oscillations takes place. The current in the other coil behaves very similarly in this case, but I have found cases in which one current oscillates, changing sign, whereas the other never changes sign.

The significance of these results lies largely in the fact that the phenomenon of reversal can occur, both in the sense of a change of polarity and in the sense of a true reversal of behaviour corresponding to a change from oscillations about one state of equilibrium to those about another. In a similar way, reversals of the terrestrial field may be occasional phenomena in the course of continual oscillations of considerable amplitude. There is some evidence that the field intensity has decreased in the past 2,000 years[5]. Such changes would affect radiocarbon dating[6], and C. Crowe (see following communication) has found that errors in such dates over the past 3,000 years might well be consistent with an increase and then a decrease of the Earth's field. Thus, oscillations of the main field with a period of some thousands of years, with reversals at intervals of hundreds of thousands of years, would be quite conceivable.

There is no guarantee that the homogeneous dynamo believed to exist in the Earth's core will behave similarly to two coupled dynamos. I hope to examine some more elaborate models which may be more closely analogous to the former, but it would be unwise to press the analogy too far. For example, two dynamos of a scale appropriate to the core would have periods measured in years rather than thousands of years; Bullard[3] has suggested that this is because the system includes nothing equivalent

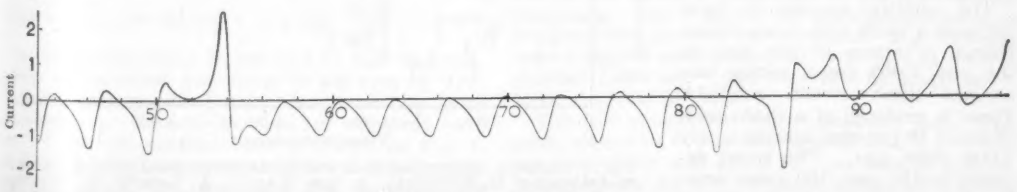

Fig. 1. Current in one dynamo vs. time (in units scaled to become dimensionless). The equilibrium values of the current are $\pm 0{\cdot}5$

to a Coriolis force. (The periods of days observed in some magnetic stars[7] might, however, be reproduced by this model.) Nevertheless, the fact that large-scale oscillations in this simple system can lead to reversals is surely an indication that the origin of reversals of the Earth's main field, and the nature of its variation with time, "though puzzling questions, are not beyond all conjecture".

I wish to thank the National Research Council of Canada for a fellowship supporting this research, and the University of Cambridge Mathematical Laboratory for use of EDSAC II.

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July 10.

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Carbon-14 Activity during the past 5,000 Years

Variations during the past 5,000 years of the concentration of carbon-14 in living material have been investigated with the aid of available radiocarbon dating measurements made with samples which have died at known times.

If the difference, Δt, between the actual age t and the radiocarbon age t' of a specimen is attributed to an initial activity not the same as that of present living material, the change in activity relative to that of the present is given by:

$$R = \frac{\Delta a}{a} \doteq \lambda \Delta t \quad (\lambda \Delta t \ll 1)$$

where $\Delta t = t - t'$ and $\lambda = 1{\cdot}24 \times 10^{-4}$ year^{-1}.

This ratio has been calculated in cases where both a radiocarbon and a reasonably accurate historical or archæological date are available[1]. First, account must be taken of systematic errors in t', chiefly of the use by most radiocarbon dating laboratories of different standards of present activity. This has been attempted by comparing the ages obtained in cases where laboratories have dated the same sample or different portions of a specimen. The scheme adopted, which correlates the results from the various laboratories with those obtained at Groningen, is shown in Table 1. Change in activity (R) *versus* time is shown in Fig. 1.

The activity appears to have followed a cycle with a maximum change of about 10 per cent in the past 5,000 years, taking into account some recent results[2,3]. There is evidence of a sharp peak of about 10 per cent approximately 2,000 years ago. The rapid decrease in the past 100 years or so has been attributed to the 'Suess' effect of dilution of the atmospheric reservoir of carbon-14 due to combustion of fossil fuel[4].

Table 1. Scheme correlating results from other laboratories with those from the University of Groningen

Years to be added to or subtracted from all dates	
University of Heidelberg	−375
University of Chicago	0
Institute of Archæology	0
Lamont Geological Observatory	+400
University of Michigan	+400
Swedish Geological Survey	+525

The estimated error of ±100 years in these corrections is not included in the activity error.

Regional differences in activity greater than 1 per cent are precluded by the treatment of data in this paper. Evidence for differences of less than about 1 per cent during the past few centuries has been given[2].

Errors in radiocarbon dates of the magnitudes found may be produced by the variations in the intensity of the Earth's magnetic field which have been indicated by measurements of the remanent magnetism of Roman bricks[5]. A cyclical variation in intensity corresponding to that of the activity would not conflict with a dynamo theory of the origin of the Earth's field (Allan, D. W., preceding communication), or with previous work on variations over a long period of the Earth's magnetic dipole[6]. It has been suggested that some activity changes may be due to variations in vertical mixing in the oceans[3]. A recent analysis of the 'Craig' carbon-14 reservoir model[3] indicates that a change of about 10 per cent in the activity would be caused by a change of approximately 100 per cent in the rate of production of carbon-14. Changes of several hundred per cent have been observed in the intensities of the secondary cosmic-ray neutrons[7] and other components[8] following large solar flares, and the effect of such events, though years apart, may be significant.

Changes in activity may be due to combinations of these effects. A recent communication[9] suggests a method of separating the effect of variation in the intensity of the magnetic field from the others. It is hoped that the above results will provide some information for further work.

Thanks for their advice are due to Mr. R. M. Cook, reader in classical archæology, and members of the Department of Archæology and Anthropology, the Sub-Department of Quaternary Research, and this

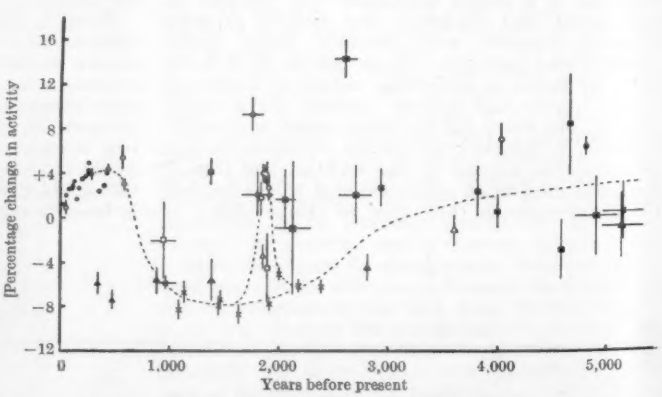

Fig. 1. Change in activity relative to that of the present *versus* time. ■, Chicago; ●, Groningen; ○, Heidelberg; △, Inst. of Arch.; ▲, Lamont; □, Michigan; ×, Stockholm; – – – proposed trend. Error in time is ±100 years or less where not shown. The Groningen and Heidelberg results in the past 500 years are obtained from refs. 2 and 3

Department. Assistance in the form of a scholarship from the Royal Commission for the Exhibition of 1851 is gratefully acknowledged.

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Department of Geodesy and Geophysics,
Cambridge. July 12.

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Infra-Red Transmission Limits and Reflectivity of Lithium-6 Fluoride and Lithium-7 Fluoride

THE Industrial Group of the United Kingdom Atomic Energy Authority has made small quantities of lithium compounds, containing different proportions of the isotopes ^{6}Li and ^{7}Li, available to its Research and Development Laboratories at Capenhurst. The material is being used to determine how altering the isotopic ratio ^{6}Li/^{7}Li in lithium compounds affects certain physical properties of these compounds.

Some of the material has been converted to lithium fluoride from which single crystals have been grown in the Natural Philosophy Department, Aberdeen. In the past nine months, several dozen single crystals of lithium fluoride containing different amounts of the isotopes lithium-6 and lithium-7 have been grown there.

Most of the specimens have been slender rods for thermal conductivity measurements, but plates from 1-in. diameter crystals have recently been tested in the infra-red. The results illustrate the effect of a variation in the reduced mass $\overline{M}$ on the infra-red dispersion frequency ω_0. In the notation used by Born and Huang[1],

$$\frac{K}{\overline{M}} = \omega_0^2 \left\{\frac{\varepsilon_0 + 2}{\varepsilon_\infty + 2}\right\}$$

Hence, if the force coefficient K and the dielectric constants ε_0, ε_∞ are unchanged by the isotopic substitution, then $\overline{M}\omega_0^2$ is constant and $\omega_0 \propto (\overline{M})^{-\frac{1}{2}}$. The reduced masses for ^{6}LiF and ^{7}LiF are 4·570 and 5·125, respectively, and so the infra-red dispersion frequencies ω_0 should be in the ratio $\dfrac{\omega_0(6)}{\omega_0(7)} = 1{\cdot}059$.

A crystal containing 90 per cent of ^{6}LiF was compared with another containing 95 per cent of ^{7}LiF. Here a frequency ratio 1·051 : 1 is obtained by linear interpolation. Reflectivity data for the short-wave end of the rest-strahlen band is shown in Fig. 1. A Hilger double-beam spectrometer with a potassium bromide prism was used, and the radiation was incident at 20° to the normal on a polished (100) surface. Tests for scattered light were made with barium fluoride and cadmium fluoride filter plates. At wave numbers below 450 cm.$^{-1}$ a considerable correction was required, but above 500 cm.$^{-1}$ the effect was small. The data were scaled by direct substitution of a heavily aluminized optical flat for which 97 per cent reflectivity was assumed.

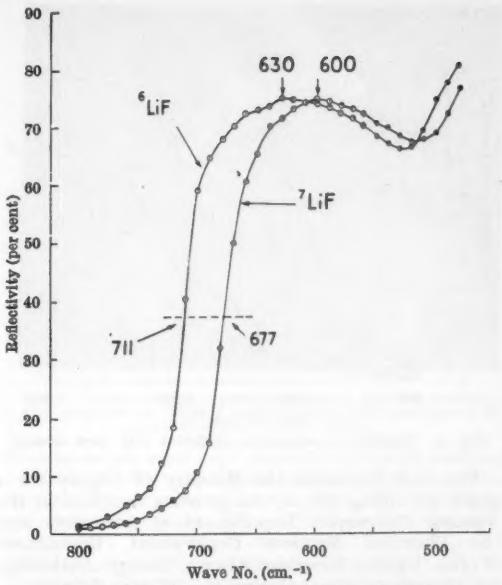

Fig. 1. Variation of reflectivity with wave number

The lithium fluoride band has a subsidiary short-wave peak as described by Hohls[2]. This peak occurs at 630 cm.$^{-1}$ for the ^{6}LiF-rich crystal, and at 600 cm.$^{-1}$ for the ^{7}LiF-rich crystal, giving the expected frequency ratio 1·05 : 1. For both specimens the reflectivity at the subsidiary peak was 75 per cent. A further test can be made in the steeply rising section of the curve by comparing the wave-numbers at which reflectivity reaches 37·5 per cent, that is, one-half of the subsidiary peak value. This occurs at 711 cm.$^{-1}$ for the ^{6}LiF-rich crystal and at 677 cm.$^{-1}$ for the other. The ratio is again 1·05 : 1.

Assuming that the sudden rise in reflectivity occurs in the neighbourhood of the longitudinal lattice frequency ω_L, then ω_0 can be derived from:

$$\omega_0^2 = \left\{\frac{\varepsilon_\infty}{\varepsilon_0}\right\} \omega_L^2$$

Since for lithium fluoride $\varepsilon_0 = 9{\cdot}27$ and $\varepsilon_\infty = 1{\cdot}92$ the wave number equivalent to ω_0 should somewhat exceed 324 m.$^{-1}$ for pure ^{6}LiF and be somewhat less than 308 cm.$^{-1}$ for pure ^{7}LiF.

The useful transmission limit of an alkali halide crystal also varies in proportion to the rest-strahlen frequency. Fig. 2 shows the absorption coefficient k in cm.$^{-1}$ for the two concentrations. The ^{6}LiF-rich crystal reaches an absorption $k = 1$ cm.$^{-1}$ at a wave number 1,634 cm.$^{-1}$ and the ^{7}LiF at 1,542 cm.$^{-1}$. Here the ratio is 1·059 : 1.

The ^{6}LiF crystal was spectroscopically pure. The main impurities in the ^{7}LiF crystal were $0{\cdot}6 \times 10^{-3}$ per cent of tin and $1{\cdot}2 \times 10^{-3}$ per cent of carbon. Measurements on the refractive indices of the two materials are being made.

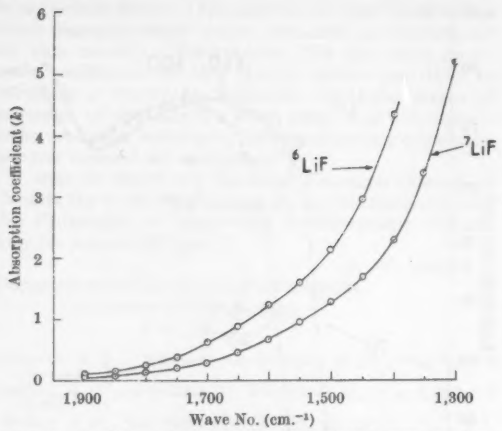

Fig. 2. Variation of absorption coefficient with wave number

We wish to thank the Ministry of Supply for a grant providing the crystal-growing facilities in the Natural Philosophy Department at Aberdeen, and the Chemical Services Department, Capenhurst Works, United Kingdom Atomic Energy Authority, for preparing and analysing the lithium fluoride.

We also thank Dr. D. C. McKean, of the Chemistry Department, Aberdeen, for the loan of a spectrometer equipped for this range, and Mr. W. Mitchell for assistance in the construction and operation of furnaces.

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P. T. Nettley
Research and Development Branch,
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Industrial Group, Capenhurst, Nr. Chester.

June 18.

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X-Ray Study of Rare Phosphate Minerals

A rare phosphate mineral assemblage is found in an abandoned mica pegmatite in Sorhee mica mine, north of Laldaiya Pahar (24° 47′ N., 86° 10′ F.; Survey of India, Sheet 72 *L*/1), Monghyr, Bihar. The main pegmatite, worked over a zone of about 200 ft. with a width of nearly 130 ft., intrudes schistose rocks striking N. 25° W. with a dip of about 60° towards W.S.W. The rare phosphate minerals occur as an aggregate, forming bands sometimes more than 2 in. wide and 8 in. long, veined with quartz. The X-ray powder diffraction study shows that the phosphate assemblage consists of graftonite (pale pink) and triphylite (bluish green) with traces of heterosite (purple). A brown mineral, the powder pattern of which is identical with that of rhodonite (manganese silicate), and an unidentified black mineral with rhodochrosite, pyrolusite, hæmatite and amorphous admixtures are also associated in the assemblage.

Penfield[1] first described graftonite, in coarsely laminated intergrowth with triphylite, from a pegmatite near Grafton, New Hampshire. The X-ray single crystal data and powder-spacing data of graftonite, found associated with arrojadite in nickel plate pegmatite, S. Dakota, were reported by Lindberg[2]. Bjorling and Westgren[3] and also Gossner and Strunz[4] gave single-crystal data of triphylite from Varutrask and Hagendorf. Heterosite occurs as a secondary phosphate mineral, formed by the oxidation of triphylite[3,5]. A black lustrous mineral[5,6] occurs as an alteration product of the phosphate minerals, but no detailed examination of this mineral was made.

The unit-cell dimensions (Table 1) were obtained from sets of rotation and zero-layer Weissenberg photographs of a small cleavage fragment of graftonite about the three crystallographic axes. The powder spacing data of this graftonite are identical with those of Rice pegmatite, New Hampshire, and differ considerably from those of Lindberg's nickel plate pegmatite, S. Dakota. The spectrum analysis of this graftonite shows mainly iron, manganese, calcium and phosphorus with small amounts of magnesium, aluminium, nickel, copper, sodium and potassium and traces of lithium, cobalt and tin. Lindberg's chemical analysis of graftonite shows mainly iron, manganese, calcium and phosphorus with small amounts of sodium, aluminium, magnesium and lithium (no potassium) and traces of tin, zinc and copper. The unit-cell dimensions (Table 1) were obtained from sets of rotation and zero-layer Weissenberg photographs about two crystallographic axes of a small cleavage fragment of pale blue triphylite, which is usually unfavourable for single crystal work.

Table 1

	Cell dimensions (A.) a_o	b_o	c_o	Axial angle β (deg.)	Axial ratios $a_o : b_o : c_o$
Graftonite Mica-pegmatite (Monghyr, Bihar)	8·89	11·57	6·16	99° 6′	0·768 : 1 : 0·532
Nickel-plate pegmatite (South Dakota) (ref. 2)	8·87	11·57	6·17	99° 12′	0·766 : 1 : 0·533
Triphylite Mica-pegmatite (Monghyr, Bihar)	6·02	10·36	4·72		0·581 : 1 : 0·455
Varuträsk (ref. 3)	*6·04	10·37	4·71		0·582 : 1 : 0·454
Hagendorf (ref. 4)	*6·00	10·34	4·67		0·580 : 1 : 0·452

* kX.

The powder-spacing data of the purple mineral were found to be identical with those of heterosite from Varutrask pegmatite[3]. The powder-spacing data of the brown mineral correspond almost exactly with those of rhodonite (manganese silicate)[7]. The powder photograph of the dark brown and black mineral grains records faintly the powder lines of rhodochrosite ($MnCO_3$)[8], pyrolusite (MnO_2), hæmatite and a strong broad band or halo, which is characteristic of amorphous admixture associated with cryptomelane; but the powder-spacing data of the main constituent in the black mineral grains do not correspond with those of cryptomelane or of any known manganates or manganese-oxide minerals. The spectrum analysis of the black mineral grains associated with dark brown mineral and traces of quartz shows mainly manganese and iron with considerable amounts of silicon, magnesium, aluminium, calcium and phosphorus, small amounts of potassium, sodium, and copper and traces of vanadium, nickel, silver and platinum (no lithium).

Grateful acknowledgment is made to the Director for kind permission to publish these results, to Dr.

A. G. Jhingran for valuable discussion and to Dr. A. P. Subramaniam for initiating this investigation.

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Cultivation of Apple-fruit Tissue *in vitro*

The *in vitro* culture of meristematic tissues derived from roots, tubers, stems, galls and tumours has received much attention, but little is known of the growth requirements of tissues of mature parenchymatous fruit walls (for a definition of the latter term, see ref. 10). The only two tissues of this type which appear to have been cultured are mature avocado pericarp[1] and mature citron mesocarp[2]. In the former tissue active cell division is occurring, but it is unlikely that many cells of the latter tissue are dividing[3]. In the developing apple-fruit, cell-division is completed within 20 days after fertilization, and subsequent growth is due entirely to cell enlargement[4]. In this report the *in vitro* cultivation of tissue derived from apple-fruits both before and after cessation of cell division is described. This appears to be the first successful *in vitro* cultivation of a pome-fruit tissue.

Surface-sterilized fruitlets (diameter *c.* 10 mm.; about 15 days from fertilization) of the varieties Sturmer Pippin, Granny Smith and Cox's Orange Pippin were cut into three pieces by two parallel transverse cuts. The entire centre pieces (thickness 2 mm.) were seated aseptically on agar media (0·5 per cent of Davis agar) with one cut surface contacting the medium. Neither White's medium[5] nor White's medium supplemented with coconut milk induced growth from Sturmer explants. On White's medium[5] supplemented with cysteine 10 p.p.m., calcium pantothenate 0·2 p.p.m., inositol 0·2 p.p.m., biotin 0·2 p.p.m., 2,4-D (2,4-dichlorophenoxyacetic acid) 6 p.p.m., and coconut milk at 10 per cent by volume, explants of all three varieties grew actively. A large number of centres of proliferation developed on the cut surface of cortex and pith. The new tissue has been subcultured and maintained in growth by the liquid-culture technique of Caplin and Steward[6].

Tissue from relatively mature fruits has also been cultured. Disks of tissue (thickness × diameter, 2 mm. × 7 mm.) were excised aseptically from near the equatorial plane of surface-sterilized fruit (variety Sturmer Pippin, 110–130 days from fertilization) so that a sepallary or petallary vascular bundle ran centrally through each explant. The growth-rate of these explants was more than ten times the rate of growth of identically excised explants from the mid-cortex and mid-pith. The medium previously used for the cultivation of fruitlet tissue with the 2,4-D concentration reduced to 1 p.p.m. induced active growth on the surface of nearly all explants. The

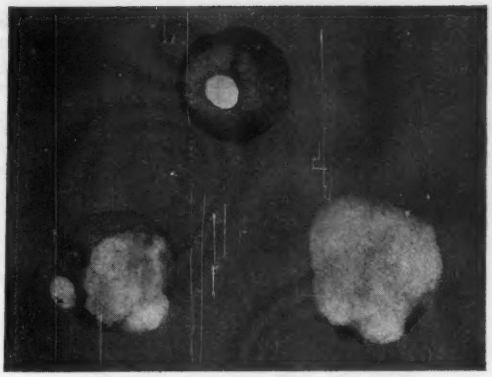

Fig. 1. Sturmer-Pippin explants (excised 110 days from fertilization and cultured on agar media) showing the development of growth from the vascular bundle

corresponding medium without coconut milk (medium 1) induced only very slight proliferation on approximately 35 per cent of the explants, the remainder showing no growth. The addition of *l*-asparagine to medium 1 (resulting concentration 150 p.p.m.), yielding medium 2, was slightly stimulative, but no detectable stimulation was produced by the addition of pancreatic digest of casein to medium 1 (resulting concentration 200 p.p.m.), or by doubling the nitrate content of medium 1. A marked stimulation of growth was observed in each case when coconut milk, aqueous extract of immature maize seed or 6-furfurylaminopurine was added individually to medium 2 to give concentrations of 10 per cent by volume, 850 p.p.m. of total solids and 0·2 p.p.m. respectively. Addition of casein hydrolysate to medium 2 did not significantly increase the growth-rate of explants. The further addition of gibberellic acid and 2-benzthiazolyloxyacetic acid (both at three concentrations) did not produce any significant effect.

The response from coconut milk was probably due to the specific factors present in this fluid which stimulate cell division. If the increased growth-rate was merely due to the presence of additional amino-acid nitrogen, a response to casein hydrolysate might have been expected[7,8]. Removal of 2,4-D from medium 2 supplemented with coconut milk yielded an almost inactive medium. Sturmer apple tissue therefore responds to coconut milk only in the presence of 2,4-D (the effects of other auxins have yet to be investigated). Potato-tuber tissue also has this unusual double requirement for growth *in vitro*[9]. Avocado pericarp and citron mesocarp appear to proliferate *in vitro* without stimulants of the type found in coconut milk[1,2].

The growth of new tissue in culture was mainly from the cut surface of the vascular bundle on the centre of the explant (see Fig. 1). Less active centres of growth sometimes developed on the surface of the explants but their contribution to the total growth was usually small. The new tissue had a white appearance resembling carrot tissue grown on solid media, and was composed of very small cells, about 1/70 of the volume of the explant parenchyma cells. The following varieties, when within 1–3 weeks of maturity, have been cultured on medium 2 supplemented with coconut milk or on this medium with the 2,4-D concentration at 5 p.p.m.; Prince Alfred, Ben Davis, Jonathan, Delicious, Statesman, Dunns and Giant Geniton. Crab-apple tissue (95 days after

fertilization) has been cultured on medium 2 supplemented with coconut milk, centres of proliferation being induced on the transversely cut surface of both pith and cortex. Undifferentiated growth has also been obtained from immature seed tissue.

A detailed investigation of the cultivation of apple tissue *in vitro* is in progress. The work reported has been assisted by a grant from the Rockefeller Foundation. Thanks are also expressed to Dr. H. R. Thompson for statistical analyses, to Miss D. A. Bridson for technical assistance, to the American Cyanamid Company for a generous gift of 2-benzthiazolyloxyacetic acid, and to Imperial Chemical Industries, Ltd., for a gift of gibberellic acid.

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Temperature Variations in Male Cones of *Encephalartos*

In the hope that this may elicit more information than I have been able to find in the available literature, I give below a summary of observations made on the diurnal rise and fall of temperature in ripe male cones of *Encephalartos altensteinii* Lehm. and *E. lehmannii* Lehm.

Cones cut from plants of *E. altensteinii* growing in the Botanic Gardens, Grahamstown, were used for demonstration purposes during the course of practical work for students of botany, and reference was made to the fact, known to me since childhood, that such male cones, when ripe, become heated. Search of the literature available produced only one reference to this phenomenon[1], in support of my statement, and a rough test was therefore made on a cone to show the truth of the assertion. A thermometer, registering 21° C. in the laboratory, was inserted between the sporophylls of the male cone at a part which was obviously the warmest to the hand: within a matter of seconds, this thermometer registered 35°. During the course of the afternoon, the thermometer registered a rise to 37° (as against an air temperature of 20°) within the cone. This cone was at the stage of shedding pollen and had been removed from the parent plant two days before, being kept on a laboratory bench meanwhile. When discussion with workers whose knowledge of the genus *Encephalartos* is greater than mine, showed that this temperature rise was unknown to them, further rough tests were made on several cones.

These preliminary tests soon showed that besides this remarkable rise in temperature there is a diurnal rhythm, the temperature of the cones rising from about eleven or twelve o'clock in the day, to a maximum about five o'clock in the afternoon, and then falling again until it is the same as, or very close to, the air temperature of the room. The tests were carried out with several cones over a period of several days in the laboratory, and a set of fresh cones was obtained, which gave the same results.

As these were observations made on cones cut from the plant, male cones still *in situ* were also tested. These also showed a great temperature rise and difference between the air temperature and that of the cones, during the afternoon hours.

Tests made on *E. lehmannii* Lehm. do not show the same great rise and fall, but there is apparently some rise of temperature in male cones of this species also. Cones of *E. villosus* were also tested but these were rather far advanced: also, the cones are more open in structure and, perhaps for these two reasons, no results were obtained showing any rise.

A fuller account of these facts will be published later, but if any workers on the Cycadales have information on such a rise of temperature in male cones or know of references in the literature to this fact, apart from the one I have given, their help will be appreciated. It is certainly true, as Gaussen says, that "le cône présente une veritable fièvre", and it would seem that there must be more information either published or known.

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Root Nodules of *Coriaria*

The shrubby genus *Coriaria* is one of the eight non-legume Angiospermous genera known to have the capacity of forming root nodules in response to infection from the soil by a symbiotic organism. In some instances, in confirmation of earlier work, the nodules of most of these genera have been shown by my collaborators and me[1,2] to be nitrogen-fixing, but, despite efforts extending over several years, I have not yet raised nodulated plants of *Coriaria* in culture, owing to an apparent difficulty in securing infection of the roots under artificial conditions. However, the results of Kataoka[3] make it probable that *Coriaria* nodules also are nitrogen-fixing.

As pointed out by Good[4] this genus is at present characterized by extreme 'discontinuity' in the sense that it occurs in widely separated regions, chiefly Japan, New Zealand, the Mediterranean region, and Central and South America. So far as I am aware it is only in respect of Japan that records of nodulation in *Coriaria* are to be found in the literature[5]. From correspondence with New Zealand botanists and from material gratefully received from them it is clear that nodulation occurs in that country also. Despite the attention paid by earlier European botanists to the presence of nodules in *Alnus*, *Hippophaë* and *Elaeagnus*, there seems no previous record of the inspection for nodules of the roots of *Coriaria* species native to Europe. Through the good offices of Mr. N. Y. Sandwith, of the Royal Botanic Gardens, Kew, inquiries were made of Dr. P. Montserrat, of Barcelona, with the result indicated in the following communication, which has been translated from the Spanish by Mr. Sandwith.

It has been suggested elsewhere[6] that the geochemical significance of fixation by non-legume nodules must not be overlooked. For example, in New Zealand, which is recognized as deficient in native legumes, the widespread species of *Coriaria* are possibly the main native source of symbiotically fixed nitrogen. The present discontinuous distribution of the genus, noted above, probably indicates that in former times the genus was represented in many regions from which it has now disappeared, and was thus in a position to contribute to the supply of combined nitrogen for plant life in general in many areas.

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Coriaria myrtifolia, the only species of the genus occurring in the western Mediterranean region, is extraordinarily abundant in the less dense woodlands of the Spanish provinces of Gerona and Barcelona (eastern part) at altitudes of 200–600 m., reaching occasionally to 1,000 m. and also descending in gullies to sea-level. It is more localized in the provinces of Lérida and Tarragona, and rare in more southerly provinces. It occurs, but is not now regarded as native, in Portugal[1]. The species reappears in the western Rif and Algeria, and also in the island of Ibiza[2], while in southern France it extends from the Gironde to the Alpes Maritimes, penetrating into Italy as far as part of the Apennines. Its occurrence in Sicily and Greece is doubtful.

On examining the root systems of young plants of *C. myrtifolia* in two localities, in the provinces of Barcelona and Lérida respectively, clearly evident root nodules were observed, resembling closely those described for Japanese material[3] and others shown in photographs provided by Dr. Bond of New Zealand material. Difficulty was experienced in locating the nodules on old plants.

It may be added that the species attains its optimal development in the humid climates where *Quercus ilex* is dominant. It prefers strong clay soils and is markedly heliophilous, being found especially along the borders of roads, streams and woodland; it is commonly associated with *Prunus spinosa* and species of *Rubus* and *Clematis*, and de Bolós[4] has provided a full ecological study of the *Rubeto–Coriarietum* association.

The fertility of soils where *C. myrtifolia* occurs plentifully is an accepted fact. In some evergreen oak woods the species makes a complete ground cover, and could be of some importance in forest economy if appreciable fixation of nitrogen occurs in the root nodules. It may be noted that thousands of tons of leaves of *C. myrtifolia* were formerly collected each year for use in tanning leather.

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Fluorescent Pigment of *Microsporum*

In a previous communication, Wolf[1] reached the conclusion that the fluorescent pigment produced by *Microsporum canis* Bodin and *M. gypseum* Guiart and Grigorakis was a pteridine. The fluorescent substance was extracted from cultures of both fungi grown *in vitro* upon hair and on a synthetic medium. The conclusion as to the pteridine nature of the pigment was based upon ultra-violet absorption spectra, fluorescence spectra, and paper chromatography of a purified material, and is consistent with the results of earlier chemical studies[2,3].

Since then, Chattaway and Barlow[4] have challenged this conclusion, without however adding any new evidence, and have raised questions concerning the nature of fluorescent materials in uninfected hair and in naturally infected hair which neither they nor ourselves can answer at the present time. Recently, Rebell *et al.*[5] have shown that the fluorescent material of rat hair is *l*-kynurenine, but the nature of the fluorescent substance in human hair has not been established. It is the purpose of this communication to present additional evidence as to the pteridine nature of the *Microsporum* pigment derived from infra-red studies and bioassay.

Cultures of *Microsporum canis* and *M. gypseum*, grown upon hair and upon a synthetic medium, were extracted with water by autoclaving for 15 min. The fluorescent material was adsorbed on charcoal, eluted with methanol, and passed through a column of alumina as previously described[1]. The methanol extracts were evaporated to dryness, and potassium bromide pellets containing the fluorescent substance were examined in the infra-red with a Perkin–Elmer model 21 spectrophotometer. The spectra are shown in Fig. 1.

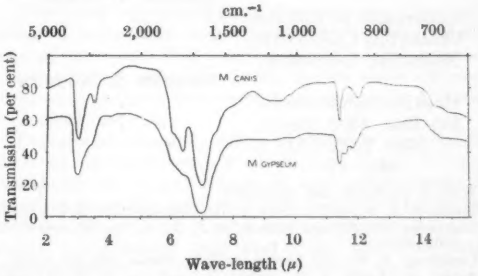

Fig. 1. Infra-red absorption spectra of the fluorescent pigments of *Microsporum canis* and *M. gypseum*

For *M. canis*, the absorption maxima found were as follows: there was a large peak at 3,375 cm.$^{-1}$, indicating an —OH or an =NH group, a small peak at 2,875 (possibly C—H), a shoulder at 1,700 (—$CONH_2$), a medium peak at 1,580 (—NH_2), a large peak at 1,440 (possibly C—H), a shoulder at 1,380 (—$CONH_2$), a broad peak at 1,040–1,100 (—NH_2), a large peak at 880 and a small one at 840 cm.$^{-1}$ (both of C—H).

The spectrum for *M. gypseum* was quite similar. There was a large peak at 3,375 cm.$^{-1}$, a shoulder at 2,950, a shoulder at 1,580, a large peak at 1,440, a shoulder at 1,350, a large peak at 880 and small peaks at 865 and 855 cm.$^{-1}$. The relatively small number of peaks appears to us to refute the objection of Chattaway and Barlow[4] that our methods of preparation "would almost certainly not effect any great purification of the fluorescent material", and further indicate that our preparations had a purity

Table 1. Crithidia Factor Activity of *Microsporum* Preparation - Growth expressed as Optical Density

Additions	Alone	Folic acid added (1·0 μgm./ml.)	Pteridine added* (1·0 μgm./ml.)
None	0·08	—	–
Folic acid (1·0 μgm./ml.)	0·10	—	0·85
Pteridine* (1·0 μgm./ml.)	0·10	0·86	—
M. gypseum preparation (0·001 ml./ml.)	—	0·44	0·10
(0·01 ml./ml.)	—	0·84	0·10

* 2-NH_2, 4-OH, 6-trihydroxypropyl pteridine was used here as a source of Crithidia factor.

greater than those examined by Robinson, Figge and Bereston[6] in their infra-red studies of the fluorescent material from *M. audouini*.

Biological verification of the pteridine nature of the compound from *M. gypseum* was obtained by microbiological assay with *Crithidia fasciculata*, a flagellate which requires for growth both a conjugated and an unconjugated pteridine[7]. The finding that preparations from *M. gypseum* possess growth-factor activity for *C. fasciculata* in the presence of low levels (1·0 μgm./ml.) of folic acid, but not in the presence of 'Crithidia factor' (2-NH_2, 4-OH, 6-trihydroxypropyl pteridine) indicates that the compound from *M. gypseum* is an unconjugated trisubstituted pteridine (Table 1). The substituents may be 2-NH_2 or —OH, 4-OH and 6-CH_2OH or a longer aliphatic chain which has two vicinal hydroxy groups. Three of the possible biologically active compounds, 2-NH_2, 4-OH, 6-trihydroxypropyl pteridine[8], compound *A* of Forrest and McNutt[9], and compound *C* of Van Baalen *et al.*[10] are ruled out because of differences in infra-red spectra.

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Experimental Ringworm in Guinea Pigs: Oral Treatment with Griseofulvin

In an effort to find a satisfactory agent for the topical treatment of ringworm and other superficial mycoses, many substances, including antibiotics, have been investigated in the past. Although high anti-fungal activity has often been demonstrated by tests *in vitro*, such compounds have given disappointing clinical results when applied topically, and it is now recognized that this is probably due to the inability of such substances to penetrate the keratin of skin, hair and nails to the site of dermatophyte activity. For this reason it has often been suggested that the eventual curative agent will be administered systemically. Wilson[1] states that "the ideal anti-fungal drug even for superficial mycoses would seem to be one which could be safely administered internally in amounts sufficient to endow the cells eventually destined to produce keratin with the power to resist fungi completely, this power persisting as they become keratinized, and the drug thus exerting its effects from within outward".

So far as I am aware there is only one published report of ringworm treatment by systemic means[2] and therefore the following preliminary account of successful treatment of experimentally induced ringworm in animals by oral administration of the antibiotic, griseofulvin, is of interest.

Griseofulvin, a metabolic product of several *Penicillium* species[3], is markedly fungistatic to many fungi *in vitro*[4] and in plants shows systemic antifungal activity[5]. Although little is known about the absorption of griseofulvin when given by mouth, it is reported to have a low mammalian toxicity and it seemed worth while investigating for possible systemic activity in animals.

Guinea pigs were infected experimentally with *Microsporum canis* and treatment with griseofulvin was commenced 10 days later when the lesions were well developed and fluoresced under Wood's light. The antibiotic was administered daily by mouth at a dosage of 60 mgm./kgm. ; control animals were given unmedicated tablets. The beneficial effect of treatment was evident clinically within four days of the administration of the first dose of griseofulvin and the highly inflammatory reaction which developed in all the control animals was prevented. Clinical findings were confirmed by killing animals from both the treated and the control group to permit histological examination. In the group treated with griseofulvin about half the hair follicles were infected after four treatments and by the eighth treatment infected follicles were present only very infrequently. Skin sections of the untreated group at these times showed that almost all the hair follicles were heavily invaded by the dermatophyte. It was noted that under Wood's light the infected hairs of treated animals fluoresced only at the tips, and microscopic examination revealed that the dermatophyte was present only in this upper part of the hair shaft. The uninfected basal portion was sharply delimited from the invaded part and malformation of the tips of the dermatophyte hyphæ, characteristic of the effect produced by griseofulvin on susceptible fungi, was seen in a number of hairs cut longitudinally in skin sections. It seems clear that the uninfected part of the hair had been formed during the treatment with griseofulvin and was resistant to invasion by the dermatophyte.

By similar experiments I have found that griseofulvin is equally effective when given orally to guinea pigs experimentally infected with *Trichophyton mentagrophytes*, and it has also been used successfully for the treatment of *T. verrucosum* ringworm induced in cattle[6]. *In vitro*, it is active in low concentrations against all the common dermatophytes.

Further studies are in progress and will be reported elsewhere, together with full details of these preliminary findings. The purpose of this communication is to make available experimental results which may

be of some importance for future progress in this hitherto unrewarding field of investigation.

I am indebted to Miss C. O. Dawson, Miss M. Mennie and Miss M. Calder for assistance and to Glaxo Laboratories, Greenford, Middlesex, for supplies of griseofulvin and pharmacological information.

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Geographical Colour Polymorphism and Chromosome Constitution in Sympatric Species of Sawflies

THE taxonomy of the *arcuata-schaefferi* group of *Tenthredo* sawflies has been a matter of interest both on the Continent[1] and in Britain[2,3] for some considerable time. The adults are strikingly similar and interspecific differences can be discerned in the females only. Good descriptions of larvæ have not been available for some of the species, and existing accounts in some cases appear vague and confusing, so that doubt exists as to whether reported differences are of inter- or intra-specific rank.

For some time now three members of this group have been the subject of extensive breeding experiments at Queen's College, Dundee, and a full account of the life-histories from egg to adult is now available. Much that is interesting has resulted from this work and some of the facts readily explain previous difficulties in larval identification. Thus it appears that larval colour polymorphism exists in two of the species, namely, *Tenthredo acerrima* Benson and *T. perkinsi* Morice. This polymorphism operates on a simple genetical basis and is related to certain geographical areas of the British Isles. Similarly, in *T. acerrima* intra-specific physiological differences revealed by examination of locomotory activity have resulted in interesting information on the geographical and genetical aspects of such differences.

It has proved impossible to hybridize *T. acerrima* Benson, *T. perkinsi* Morice and *T. arcuata* Forst, and in fact copulation has not been observed although there was ample opportunity for it to occur. Host-plant preference is marked but not absolute, *T. arcuata* and *perkinsi* being associated with white clover (*Trifolium repens* L.) and *T. acerrima* with bird's-foot trefoil (*Lotus corniculatus* L.). The colour and markings of *T. acerrima* larvæ are clearly different from those of either *T. arcuata* or *perkinsi*. In the penultimate instar, however, the larvæ of the last two species resemble each other somewhat, so that it is pleasing to find that there are cytological differences. In *T. arcuata* the male larvæ produced parthenogenetically have a haploid number of 15 chromosomes, whereas female larvæ have a diploid number of 30, but *T. perkinsi*, on the other hand, possesses a haploid number of 18 and a diploid number of 36. Biological, morphological and cytological evidence thus combine to suggest specific rank for these three insects.

In at least one very local and limited area, however, the species *T. acerrima* appears to be variable cytologically as well as morphologically and physiologically. While several *acerrima* larvæ show a haploid chromosome number of 18 and a diploid number of 36, members of one particular brood gave counts of 21 and 42 respectively, possibly the highest number recorded in Tenthredinidae. Inter-breeding of this aberrant brood with 'normal' individuals from the same area gave viable offspring with intermediate chromosome counts. The 'aberrant' and 'normal' parents, taken in the field from the same ecological area, resembled each other in appearance, and the resulting broods of intermediate chromosome count also appeared very similar. It is interesting therefore to find that a survey of the locomotory activity of these same broods showed that they differed in behaviour from what had previously been considered normal for the wild types taken in the area.

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Different Frequencies of Supernumerary Chromosomes in Diploid Populations of *Dactylis glomerata* in Israel

WHETHER supernumerary chromosomes have any selective advantage is still in doubt[1–3]. One possible way of attacking this problem is to find out whether natural populations of a given species show different frequencies of such accessory chromosomes in different ecological habitats.

Dactylis glomerata L. offers favourable material for such an examination. Both diploid ($2n = 14$) and tetraploid ($2n = 28$) forms of this group occur in Israel, where they occupy a rich variety of ecological niches. In diploid plants supernumerary chromosomes of standard size and form are frequently encountered.

Three diploid populations were examined as to the frequency of supernumerary chromosomes in them. In each case, a sample of plants was taken at random in the early winter of 1958, transferred to Jerusalem and examined in the spring. Chromosome counts were made at diakinesis and metaphase I in aceto-carmine squashes of pollen mother cells. The results of this examination are given in Table 1.

The Safad sample was taken from a population growing on the northern outskirts of Safad, Upper

Table 1. FREQUENCY DISTRIBUTION OF SUPERNUMERARY CHROMOSOMES IN THREE DIPLOID POPULATIONS OF *Dactylis glomerata* L. IN ISRAEL

Locality	Total No. of plants examined	No. of supernumeraries 0	1	2	3	4	Supernumeraries per plant	Supernumerary carriers (per cent)
Safad	75	37	24	11	3	–	0·73	50·70
Mount Kenaan	31	23	5	1	2	–	0·42	25·80
Jerusalem	80	57	20	2	1	–	0·34	28·75

Galilee. The plants were growing on a steep north facing slope, altitude 750 m., and on light Rendzina soil derived from chalky Senonian bedrock.

The Mount Kenaan sample was collected approximately 2 km. north of Safad. This place is characterized by terra-rossa soil on hard Eocene limestone. Plants were taken from the top of a hill, altitude 950 m.

The Jerusalem sample was collected in the Valley of the Cross (Matzleva) on the western outskirts of the city. Plants were growing on a gentle slope facing west, altitude 700 m., on terra-rossa soil derived from Upper Cenomanian dolomites and limestones.

The results indicate striking differences between Jerusalem and Safad populations. Most suggestive, however, is the comparison between Safad and Kenaan. Populations here are only 2 km. apart but found on completely different soils. At the 5 per cent level, the data indicate significant differences even between these two geographically close populations. (χ^2 test for homogeneity, plants with 2 and 3 supernumeraries grouped together: $\chi^2 = 6{\cdot}31$; $P \sim 0{\cdot}03$.) On the other hand, the Jerusalem and Kenaan populations seem very similar.

The examination suggests that *Dactylis* populations occupying different ecological habitats do differ from one another in regard to the frequency of supernumerary chromosomes. Such a difference could be attributed to different selective advantage of supernumeraries in different habitats.

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Spray-collecting Area of Locusts and their Susceptibility to Insecticides

Locust swarms may be sprayed with insecticides when the insects are settled or in flight. Techniques have been developed for the estimation of the amount of spray collected by individual locusts[1–4], and fundamental to their interpretation is the spray-collecting area of a locust. Two areas have been used for calculations: the plan area for settled locusts[1,2], reduced to allow for the less vulnerable parts, and the 'horizontal equivalent area' for flying locusts[3,4], defined as the horizontal plane area which, when passed through a given spray of droplets with the same velocity as a locust, collects the same number of droplets as the locust. The plan area of the desert locust, *Schistocerca gregaria* (Forsk.), is about 6½ cm.², and the horizontal equivalent area has been found experimentally to vary greatly with drop size, increasing from 30 cm.² for droplets 300μ in diameter to 450 cm.² for 50μ drops[5]. The collecting surface of a settled locust approximates to the plan area when the drops are falling nearly vertically, but at shallow angles of approach the quantity of spray deposited on the locust is many times that estimated from area dosage and plan area.

A development relating these parameters is the consideration of an area normal to the path of approach of the drops to the locust, the path of approach depending on the terminal velocity of the drops and the air-speed of, or wind-speed over, the locust. This 'normal equivalent area', a term suggested by Mr. K. F. Sawyer, may be defined as the area of a plane surface, at right angles to the path of approach of the drops, through which pass as many drops as are collected by the locust under similar conditions. Laboratory measurements of this area (see Table 1) can most easily be made by comparing the quantity of spray picked up by a locust with the quantity deposited on a sphere under the same conditions, due allowance being made for the droplet-collecting efficiency of the sphere.

Table 1. The Spray-collecting Areas of the Locust (cm.²)

Settled locusts

Plan area for 10 males, 5·5; 10 females, 7·3. Normal equivalent area for randomly orientated locusts (spray droplets of 50–230μ and wind speed of 2 m./sec.) 5–6

Flying locusts

	Drop diameter (μ)			
	50	100	200–230	300
Horizontal equivalent area (ref. 5) (♂ and ♀)	445	110	46	31
Normal equivalent area (ref. 5) ♂	8·6	8·7	9·4	—
♀	9·9	11·0	11·2	—

In experiments with settled locusts, of unconstrained and variable orientation, the mean horizontal equivalent area was found to be 5–6 cm.² for uniform sprays from drops of 50, 100 or 230μ in diameter drifting over the locusts at 2 m./sec. At lower wind-speeds the values of the normal equivalent areas were reduced owing to a decreased collection efficiency of the locusts. For locusts flying through a falling spray, the normal equivalent area was found to be about 9 cm.² for males and 10½ cm.² for females, being virtually independent of the droplet diameter over the range 50–230μ.

The deposit on a locust from a uniform spray will be given by the product of the normal equivalent area, concentration, and path-length through the spray. The relative quantity of spray picked up by flying and settled locusts subjected to the same concentration of spray at the same relative wind speeds will be proportional to their normal equivalent areas. The flying locusts therefore collect nearly twice as much spray as the settled ones. Furthermore, the deposit on a settled locust can be expected to exceed the corresponding area dosage on a horizontal surface by a factor approximating to the cosecant of the angle of approach of the spray, measured from the horizontal.

When a 20 per cent solution of the insecticide 4 : 6-dinitro-*o*-cresol (DNC) in oil is sprayed over locusts, a decrease in size of the sprayed droplets from 300 to 100μ in diameter appears to cause an increase in the toxicity of the spray to both the flying and settled insects, as is shown in Table 2. The insecticide diazinon exhibits little change in toxicity with drop diameter when sprayed over flying locusts.

Table 2. *LD*50's of Insecticides Sprayed on to *S. gregaria* (μgm./gm.)

Approximate drop diameter (μ)		50	100	215	300
Locusts settled	DNC	23*	25*	26*	35
	Diazinon	—	—	6·6*	—
Locusts flying	DNC	—	16	21	30†
	Diazinon	5·4	6·0	5·6	—

* Insects constrained to lie with long axis perpendicular to path of approach of the drops.
† Ref. 5.

Combining the differences in collecting area and susceptibility, the flying locusts are thus about 2·4 times as vulnerable to sprays of 4 : 6-dinitro-*o*-cresol solution as are settled ones and about twice as vulnerable to diazinon. The difference is further enhanced when the application of these results to a particular spraying operation is considered, owing to the wind gradient near the ground which effectively reduces the path-length of the settled locusts through the spray and may also reduce their normal equivalent areas. In actual field operations with aircraft, this increased vulnerability is, at times, more than counterbalanced by the low densities of flying swarms with consequent very low kills per gallon of insecticide.

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Microscopic Structure of the Lungs of the Bottlenose Whale

One of the most remarkable structures in the lungs of Cetacea are the sphincters in the respiratory bronchioles. In a number of toothed whales (Odontoceti) the mucosa of these terminal bronchioles shows 8 to 40 consecutive ring-like folds with a circular layer of smooth muscle fibres acting as a sphincter. They may close the passage in the bronchiole completely. They divide the lumen in a number of small consecutive chambers. When the musculature relaxes the passage is re-opened by a system of radially directed elastic fibres, running from the muscular layer to the peripheral layer of cartilage. The sphincters have been described in the common porpoise (*Phocaena phocaena* (L.)), the bottlenose dolphin (*Tursiops truncatus* (Mont.)), the common dolphin (*Delphinus delphis* L.), *Prodelphinus caeruleo-albus* Meyen, the white whale (*Delphinapterus leucas* (Pallas)) and in *Berardius bairdii* Stejneger[1,4–9]. Several authors showed that these sphincters are not present in baleen whales (Mystacoceti)[2,6,7,9]. These animals show a very well-developed mass of muscular fibres in the tips of the alveolar septa. Probably these fibres are able to close the alveoles completely.

Murata[6] found a constriction in a respiratory bronchiole of the sperm whale (*Physeter macrocephalus* L.). This constriction was not found by other authors[2,9], and all agree that the typical system of consecutive sphincters is not present in the sperm whale. This fact suggests that the occurrence of the sphincters is not connected with the systematic position of the animals, but with functional aspects. The dives of whalebone whales and the sperm whale are deep and prolonged, and the animals have a lung capacity of about 50 per cent of that of the terrestrial mammals[2,7]. The other toothed whales do not dive very deep and very long. Their lung capacity is about 150 per cent of that of the land mammals.

To prove the above suggestion we studied the microscopic anatomy of the lungs of the bottlenose whale (*Hyperoodon ampullatus* (Forster)), a toothed whale characterized by deep and prolonged diving which has a very small lung capacity, like the sperm whale. Prof. J. T. Ruud kindly provided us with the lungs of an animal captured at the land station Steinshamn (Norway). The material was not very well preserved, but all essential characteristics could be determined.

As in all other Cetacea the connective tissue of the lungs was highly elastic. There was practically no lymphoid tissue. The bronchial epithelium and the glands contained almost no mucoid cells. These characteristics may be a result of the absence of dust in the aspired air[7]. The septa of the alveoles showed two layers of capillaries and many elastic fibres. As in Mystacoceti the tips of the septa contained a large amount of smooth musculature.

All bronchiæ showed a ciliary epithelium. At their outer side they were surrounded by a layer of irregularly shaped pieces of cartilage. This cartilage was also found in the terminal bronchioles as in all other Cetacea with the exception of *Berardius*[6]. On the inner side of the cartilage there is a layer of elastic connective tissue with a very distinctive plexus of anastomosing arteries. This arterial plexus is found even in the smallest bronchioles. The walls of the vessels are very elastic. *Delphinus* and *Phocaena* possess a venous or a capillary plexus[4,5]. The plexuses may act as shock-absorbers and they may also serve for heating the air.

At the inner side of the plexus is a very well-developed longitudinal layer of smooth musculature, as is the case in the terminal bronchioles. There are, however, no circular folds of the mucosa. Consequently the typical consecutive sphincters are absent in the bottlenose whale.

This phenomenon shows that the sphincters do not occur in animals characterized by deep and prolonged diving and of small lung capacity. They are found only in frequently breathing toothed whales with a large lung capacity. A system of consecutive cocks is used in technical constructions with great differences in pressure at either side of the cock. If the pressure must be regulated by opening the cock now and then, a series of consecutive cocks is preferable to a single one. It is highly probable that the system of sphincters must be considered as an adaptation to fluctuations of the air-pressure in the lungs during quick and frequent diving and emerging, and especially during the violent inspiration and expiration of Cetacea with a very large lung capacity.

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